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GLOBAL INVESTMENT TRENDS IN CLEAN ENERGY

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

TO

EXAMINE CURRENT GLOBAL INVESTMENT TRENDS IN CLEAN ENERGY TECHNOLOGIES AND THE IMPACT OF DOMESTIC POLICIES ON THAT INVESTMENT

MARCH 17, 2011

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GLOBAL INVESTMENT TRENDS IN CLEAN ENERGY

THURSDAY, MARCH 17, 2011

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 9:32 a.m. in room SD–366, Dirksen Senate Office Building, Hon. Jeff Bingaman, chairman, presiding.

OPENING STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO

The CHAIRMAN. OK. Why don't we get started?

Thank you all for being here. The purpose of this hearing is to gain insights into the investment environment that exists here in the United States as well as abroad for manufacturing and deployment of clean energy technology. Our competitors are moving quickly to secure an advantage in this growing market. We want to thank our witnesses for providing valuable testimony about this issue and making recommendations to us about policy in this area.

I've remarked before on the significant challenges that we face in energy in the coming decades. Our current energy sources not only endanger our long term prosperity. But also leave us reliant on unstable regions to which we are currently transferring billions of 's of our wealth every year.

Obviously this is not a sustainable situation. We have an obligation to try to address it. Passing on the ability to deal with the consequences of climate change is not something we should contemplate for future generations. Clearly we need to strengthen our own economy in these years by dealing with these issues in a forthright way.

The testimony today bolsters the case for action. It's clear that countries such as Germany and South Korea and China are devoting substantial resources to securing their place in what promises to be a multi-trillion dollar market as the developing world increases its appetite for energy in coming decades. In my view the losers in this clean energy technology race will be those who do not participate aggressively.

Competition between countries will largely take place in bringing increasingly affordable innovations to market. Setting off a cycle where clean energy sources become more and more affordable compared to incumbent technologies. The market grows to more developing countries.

Unfortunately although the United States remains a great source of innovation in the world, it is not clear that we are going to reap the benefits of that innovation or even that we will retain our advantage in innovation. Our competitors are making a compelling case to investors and entrepreneurs that it's good business to develop there rather than to develop in the United States. As the best minds follow those investments the likely result is that the next waves of innovation may take place there as well. The next generations of innovative energy technologies that will determine who will lead the world in this competitive race.

So in that sense investment choices we make now will shape the world in which our children and grandchildren live. The longer we wait to address our clean energy challenges the higher the hill will be for them to climb. I look forward to hearing what we can learn today about our current situation and what we can be doing to ensure our future leadership in this very competitive environment.

Senator Murkowski.

STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

Senator MURKOWSKI. Thank you, Mr. Chairman and good morning.

Today's hearing is on a pretty broad topic, one where the conversation often leads to comparison as to how the United States stacks up against other countries. How our policies compare. These comparisons I think we recognize can be very useful.

But in making them I think we have to be very clear about some very important factors including what our own constitution permits. How much taxpayer money we can afford to spend? What the American people will support.

Perhaps the best example of the need for honesty is our ongoing conversation about China, a country that has only partially opened its markets. The United States on the other hand operates as a capitalist democracy. In so many ways the conversation about our status verses China's rely upon perhaps an apples to oranges comparison.

Our basic approach is to governance are vastly different. So are the ways our Nations choose to make investments. So I hope that as a committee we, from the outset, recognize those pretty fundamental differences.

It's become popular, particularly when focused on energy policy to say that we're falling behind China in sort of a clean energy race. I guess I would challenge that. We can and we should work with China wherever possible to make progress on our energy challenges. But we should not merely copy what they do or how they do it whether they're in terms of total investment dollars or individual technologies.

Even China's more progressive energy policies have been imposed with less than ideal results. China has a national goal of producing 15 percent of its energy from non-fossil fuel sources by the year 2020. The Three Gorges Dam, a source of renewable energy is now producing enough electricity to replace 31 million tons of coal, reduce China's carbon emissions by 100 million tons annually.

But I think we know the story. The dam caused the displacement of several million people from their homes, from their communities.

Another Chinese project meant to help meet greenhouse gas emission reduction targets involves the construction of 13 dams in a world heritage site that is home to more than 80 endangered species. Probably go out on a limb here, but would guess that the EPA would probably block such a project if it was proposed here in the United States. Of course here in this country our policies are not perfect either.

Where we have laws like the Clean Air Act and the Clean Water Act, that have been in place for decades.

We have biofuels that have played a role in rising global food prices.

Nuclear power has left us with spent fuel that must be safely stored and the siting of transmission lines to connect renewable assets to the grid has resulted in controversy, certainly some controversy there.

I raise these issues not in an attempt to throw cold water on the enthusiasm for deploying clean energy technologies. But perhaps to provide some needed context. Remind my colleagues that the scope of the energy and the environmental challenges that we face.

I understand that many believe that we should be just as enthusiastic as China when it comes to clean energy. Others look at prices at the pump and say that we should be just as enthusiastic as China when it comes to the development of oil, of natural gas, coal and other minerals. So this is not just about lowering the cost of financing projects that we all support or finding money in the budget for subsidies.

I think it's about looking honestly at the whole picture. Devoting as much attention to identifying those areas where the government can play a constructive role as we do identifying the areas where the government is perhaps getting in the way. It's about reaching agreement on viable energy policy that addresses both of our immediate and our long term needs.

I look forward, Mr. Chairman, to the conversation this morning as we, as a committee, focus on these issues that command so much attention here on a national scene and on the international scene. Thank you.

The CHAIRMAN. Thank you very much.

Let me introduce all 4 of our witnesses. Then we'll hear from them.

Mr. Ethan Zindler is the Head of Policy Analysis with Bloomberg New Energy Finance here in Washington, DC.

Ms. Kelly Sims Gallagher is an Associate Professor of Energy and Environmental Policy and Director of the Energy, Climate, and Innovation Program at The Fletcher School at Tufts University.

Mr. Will Coleman is a partner with Mohr Davidow Ventures in Menlo Park, California.

Mr. Neil Auerbach is the Managing Partner with Hudson Clean Energy Partners in Teaneck, New Jersey.

Thank you all very much for being here. If each of you could take 4, 5 or 6 minutes and sort of give us the main points that you think we need to try to understand. We will include your entire state-

ment in the record. But we will then have some chance for questions.

Mr. Zindler, why don't you start out?

STATEMENT OF ETHAN ZINDLER, HEAD OF POLICY ANALYSIS, BLOOMBERG NEW ENERGY FINANCE

Mr. ZINDLER. There we go. Thank you very much, Senator and Mr. Chairman. I first just want to say thank you to you and to the staff for inviting me here today. It's a real honor.

You should all have before you a nine page document that I submitted in the record. I'm not going to go through all of it word by word, but I will walk through the charts that are in it. So if you would, you know, follow along with me here.

I come here today in my role as Head of Policy Analysis at Bloomberg New Energy Finance, a market research firm providing data and insights on the clean energy sector and the carbon trading markets. New Energy Finance as it was then known was founded 7 years ago in London with one express purpose. To track finance technology and policy trends in clean energy.

In December 2009 we were acquired by Bloomberg. Today we have a staff of 180 in 11 offices around the world. Our major clients include most of the top investors in this sector who are doing these investments primarily to earn a healthy return less for social purposes.

At this point I just want to say that my remarks today represent my views alone as a clean energy industry analyst. They do not represent the corporate positions of Bloomberg LP or Bloomberg New Energy Finance. In addition, they do not represent specific investment advice and should not be construed as such.

So I'm going to start today with a quick overview of investment activity globally. Before I do, just let me offer a few comments just on what our definition of new energy or clean energy is. It's renewables. It's biofuels. It's energy efficiency technologies.

I know that there's been a lot of discussion of nuclear as a noncarbon emitting source. Other firms do track investment in that sector. But I don't have numbers for that in these figures here that you're going to see today.

Overall new investment in clean energy rose 30 percent in 2010 from the year prior to an all time high of $243 billion which you'll see in figure 1 here. This came after a leveling off between 2008 and 2009 amid the economic crisis. Despite all that new capital there's still some lingering and substantial concerns among public market investors which you can see in figure 2 which shows the NEX which is an index that we run tracking 100 publicly traded clean energy companies.

As you can see the NEX which is the purple line or the purplest line suffered a sharp decline amid the economic crisis. This is not surprising. A lot of the companies in our sector are new.

It's relatively immature. There's a high degree of volatility. The NEX has bounced back. But there's still a certain discomfort among some investors about the status of the industry.

Another trend that I point out is that last year we saw a surge of new investment in so called small scale distributed generation projects which rose 90 percent to about $60 billion. This accounted

for about $1 in $4 invested in the clean energy sector overall. This was primarily—sorry, this is entirely due to installation of residential, small scale, commercial PV or photovoltaics.

Germany is the world leader and installed about 7,500 megawatts of new PV capacity last year. By comparison the U.S. was far behind at less than 1,000. Even the Czech Republic installed more PV last year than the United States did.

Turning specifically to the U.S.——

The CHAIRMAN. Is that comparison you just went through in one of these charts?

Mr. ZINDLER. Sorry, yes. The actual number of PV installations is not in the charts.

The CHAIRMAN. OK.

Mr. ZINDLER. The chart No. 3 here just gives you the overall macro figure.

The CHAIRMAN. Right.

Mr. ZINDLER. In terms of dollar investment.

The CHAIRMAN. But not PV.

Mr. ZINDLER. You can see about $55 billion in new third party capital was invested in China last year. Germany was a bit further behind at about $40 billion. The United States came in at about $35 billion. Most of that money in Germany was for the deployment of residential rooftop solar projects.

The CHAIRMAN. Good.

Mr. ZINDLER. So let's turn to the United States for a moment and we look ahead. I would say that the industry here domestically faces what we would call uncertain prospects. State renewable energy mandates or renewable portfolio standards which are on the books in about 30 States in the U.S. are not driving investment as they did several years ago. Low natural gas prices are making it difficult for wind developers in particular to compete. There's clearly ongoing uncertainty around key Federal policies.

In U.S. wind, if you look at figure number 5, we predict significant overhang of capacity in terms of manufacturing on U.S. soil of wind turbines. Last year about 5 gigawatts of new capacity were added in the United States. This year the number could be somewhere in the area of 6 to 7 to 8. But the total capacity online of manufacturing turbines is somewhere up above 10 which inevitably means that a number of these plants are either going to have to shut down or export or run at lower capacity in order to meet the market demands here.

I would like to make one point before I go on about this question of China in response to your comments, Senator Murkowski. I think that to some degree it is a little bit over simplistic to paint the U.S. and China relationship on clean energy as purely a race. We are seeing the emergence of a truly integrated supply chain between the 2 countries. A lot of this equipment that is produced in either country does contain components made in one country or the other. There's a lot of global trade that takes place.

In reality there's probably a net deficit of clean energy deficit between the U.S. and China with China exporting more than the U.S. is. But in reality it's very heterogeneous. I'm not going to walk you through figures 7 and 8. But if your staff wants to take a look one of the things that we point out is that in a typical solar modular

or wind turbine you inevitably have components from both countries.

I'm almost running out of time. So I'm just going to make one—a couple, few comments here about the so called Valley of Death conundrum here. One of the biggest impediments to further progress in the U.S. in terms of new technologies is a persistent dearth of capital for potentially lower cost, breakthrough technologies that have advanced out of the lab but still require extensive and expensive field testing and trial installations before being deployed at scale.

Financing has existed in the past for early stage, risky technologies in the form of venture capital. It is also available for late stage, lower risk technologies in the form of project financing from banks, but what about new projects that fall somewhere in between? The so called commercialization Valley of Death poses a long standing challenge to the clean energy sector just as it has to other capital intensive industries in the past.

I would argue that bridging this gap is critically important. Existing technologies do have an important role to play. But costs must come down further for clean energy to truly be competitive on an unsubsidized basis.

As you all know in response to this conundrum, Congress established the Loan Guarantee Program in 2005. That program began offering loan guarantees in 2009. The program has become a bit of a lightning rod. I would say for those on both sides of the aisle.

Those in the industry and I'm speaking here really giving hearsay on behalf of some of my clients have complained that the process of getting a loan guarantee is slow and onerous. But then I know that some in Congress have complained that the DOE has moved too quickly in offering some loan guarantees and maybe not done enough due diligence. So they are essentially taking, I would say, from both sides to some degree.

In our view the Loan Guarantee Program puts the Federal Government in a fundamentally challenging position. On the one hand it has been charged with helping to finance potentially game changing technologies. On the other, it must serve as a careful guardian of taxpayer funds.

As private sector investors know well, investing in new technologies inevitably involves a high degree of risk. We believe the Loan Guarantee Program can foster important breakthroughs but also will inevitably result in some number of failures. If the Federal Government is going to guarantee financing for technologies it must also be comfortable with the inherent potential downsides. As any serious investor in stocks, bonds or other securities will tell you having a portfolio of both winners and losers in inevitably part of the game. Success is determined by the portfolio's overall performance.

The Loan Guarantee Program aside, the fundamental challenge of the Valley of Death remains for many new companies seeking to build their first pilot scale projects. From a larger strategic perspective we would argue that whichever Nation puts in place policies or financing schemes to bridge this gap stands to reap the greatest economic benefit in the long haul. With that I would say, thank you very much for your time.

[The prepared statement of Mr. Zindler follows:]

PREPARED STATEMENT OF ETHAN ZINDLER, HEAD OF POLICY ANALYSIS, BLOOMBERG NEW ENERGY FINANCE

CLEAN ENERGY INVESTMENT TRENDS AND THE IMPACT OF DOMESTIC US POLICIES

Despite major disruptions to the global economy, new investment in clean energy has continued to surge in recent years. However, the pattern of that investment has shifted dramatically. China, a virtual non-player on the international stage as recently as four years ago, is now the undisputed leader in attracting and disbursing new capital. The US and all others trail behind by comparison. However, much remains to be played for as generating from truly clean sources generally is more costly than from fossil fuels on an unsubsidized basis. The true eventual 'winners' in any clean energy technology race will be those that can generate power or produce transport fuel at lower cost. In this regard, with its outstanding intellectual, entrepreneurial and other resources, the US is hardly out of the game. Still, with governments elsewhere recognizing the potential economic opportunity of clean energy and throwing major support behind the sector, the US runs the risk of being left further behind.

- Clean energy investment has proven surprisingly resilient, despite the economic downturn. Total new investment in the sector totalled $243bn in 2010, up from $186bn in 2009 and $52bn in 2004.
- Investment is shifting rapidly from West to East. The Europe, Middle East and Africa (EMEA) region was still tops in attracting new clean energy funding with $94.4bn in 2010. Looking at third-party private capital alone including funding for small projects, China is the undisputed single national leader with $54.4bn. Germany ($41.2bn) and the US ($34bn) lag far behind.
- China is the world's leading exporter of solar modules and top producer of wind turbines though it has exported very few of the latter to date. The US-China clean energy relationship is hardly a zero-sum game, however. Integrated supply chains allow the US to supply capital equipment and key high-value components to Chinese manufacturers. Both countries could benefit as equipment costs drop and deployment increases, creating more local installation jobs.
- Major progress has been made in recent years to cut costs of clean energy equipment, particularly photovoltaic (PV) modules. PV is now cost-competitive with fossil sources in some markets where local electricity prices are high and/or solar resources are exceptional.
- Still, much progress remains to be made on PV and technologies such as advanced batteries and next generation biofuels. A consistent problem: the so-called 'Valley of Death', which hinders projects employing new technologies from being built at scale. Venture investors are willing to take the risk on such large-scale projects but generally lack necessary funds. Banks have the needed capital but lack the appetite for risk.
- The US Department of Energy seeks to address this quandary through its loan guarantee programs. While the agency has made major progress in making such guarantees available, it has faced major challenges due to its conflicting roles.

1. INVESTMENT UPDATE

1.1. Global investment

Global clean energy investment surged 30% in 2010 to a new record of $243bn. This represents a major milestone for a sector that enjoyed an average compound annual growth rate of 37% between 2004 and 2008, but then saw growth stall in 2009 in the face of the worst recession in half a century (Figure 1)[1]. While overall growth has remained strong, however, the patterns behind the capital flows have changed dramatically. Investment is up substantially in Asia, China in particular. Installations and financings for small-scale solar have soared while wind installations and financings have slipped. Interest continues to grow in energy efficiency technologies, batteries and electric vehicles.

The largest investment asset class in 2010 was, as usual, the asset financing of utility-scale projects such as wind farms, solar parks and biofuel plants. This investment in deploying proven technologies rose 19% to $127.8bn last year.

Meanwhile, venture capital and private equity investment, which traditionally supports start-ups and new technologies had an improved year, up 28% from a rel-

[1] Figures 1–9 have been retained in committee files.

atively depressed 2009 total to reach $8.8bn. That total still fell far short of the all-time high for venture capital and private equity of $11.8bn in 2008.

Public market investment (funds raised via initial public offerings and others on the stock exchanges) bounced back from its recession-driven lows in 2008 and 2009, up 18% to $17.4bn in 2010, though well short of the record of $24.6bn in 2007. This rebound came despite weakening sentiment among public market traders regarding the sector. The WilderHill New Energy Global Innovation Index (NEX), which tracks the prices of 100 clean energy stocks traded globally, lost 14.6% of its value in 2010 and under-performed the S&P 500 by more than 20% (Figure 2).

It was investment in small-scale, 'distributed' generation projects which really stole the spotlight in 2010, surging by 91% to $59.6bn, and accounting for approximately one in four dollars invested in clean energy overall. This was almost entirely due to the installation of residential and small-scale commercial photovoltaics (PV). Germany alone saw 7.5GW of new PV capacity added in 2010, an all-time record and over one-third of the total 20.3GW installed globally. Other countries, including Italy and the UK also saw rapid growth, as did certain US states. Still, the US represented a relatively small share of the overall PV market; the Czech Republic installed nearly twice as much new solar capacity (1,727MW) in 2010 as the US (937MW).

The mass scale-up of small-scale solar is being driven by an extraordinary decline in the cost of photovoltaic modules and financial support for project investment worldwide. For several years, high demand for solar led to a bottleneck in solar-grade processed silicon. This kept prices high, even as the underlying cost structure continued to improve. That bottleneck in silicon broke in 2008, allowing prices to fall very quickly thereafter. Today, solar technology is effectively cost-competitive with fossil generation in markets with either high utility electricity prices, particularly good solar resources, or both. This includes Hawaii and Italy. As costs continue to drop in 2011 and beyond, Bloomberg New Energy Finance anticipates PV reaching 'grid parity' in markets such as Turkey, Portugal, France, Greece and California in the next 5-10 years, perhaps even much sooner.

On an individual country basis, China is now the undisputed leader in attracting new clean energy investment (Figure 3). In 2009, the country surged into the top spot of the Bloomberg New Energy Finance rankings published in conjunction with the Pew Charitable Trusts. In 2010, China extended its lead, attracting $54.4bn in new third-party private capital (venture capital/private equity, asset/project finance, small-scale financings, and public market fundings). By comparison, Germany attracted $41.2bn, primarily due to the tremendous growth in small-scale solar installations. The US finished in third place with $34bn.

It is important to note that these figures do not take into account the extraordinary but difficult-to-quantify amount of public sector support provided to the clean energy sector by the Chinese government at both the national and provincial level. Bloomberg New Energy Finance has tracked a total of $46.9bn in economic stimulus commitments to clean energy in the country. In addition, the China Development Bank made no less than $35.3bn in credit facilities available to just six domestic solar and wind equipment makers in 2010. These companies are now using these funds to bankroll entry strategies to key developing markets such as Brazil and India. Finally, there are the local tax breaks and other benefits routinely offered by provincial governments to attract clean energy investment to their regions.

The surge in new private investment in China has gone primarily to fund expansion of wind and solar manufacturing and toward wind power generating assets. Today, China is the biggest player in the export of PV modules but installs relatively few (513MW in 2010) of them domestically.

By contrast, the country's wind turbine manufacturing plants have been producing equipment that has been deployed almost entirely locally to date. In 2010, China set a global record with 17GW of new wind power generating projects installed representing almost half of all capacity added worldwide last year. By comparison, the US installed approximately 4.9GW in 2010, down from 10GW in 2009.

Longer term, China's wind turbine makers hope to match the success enjoyed by the country's PV equipment makers. Backed with substantial capital raised on the public exchanges and from the China Development Bank, they look to enter markets including Brazil, Turkey, India, various parts of Africa, and the US.

1.2. Clean energy investment in the US

As recently as three years ago, the US was the top country in attracting new clean energy investment, thanks to a surge of investment in new wind and corn ethanol projects (Figure 4). However, funding fell dramatically in the first half of 2009 in the wake of the global financial crisis as credit for new wind, solar, geothermal and biofuels projects became difficult to secure. Investment bounced back in the sec-

ond half of 2009 and into 2010 thanks to significant support from the American Recovery and Reinvestment Act (ARRA), which allocated $63bn to clean energy companies and projects. Today, the sector faces uncertain prospects. State renewable energy mandates (renewable portfolio standards) are not driving investment as they did several years ago; low natural gas prices are making it difficult for wind in particular to compete; and uncertainty remains around key federal policies.

Investment in large-scale projects in the US has been hampered since the onset of the financial crisis in Q4 2008. At that time, it was 'tax equity' investors that were primarily responsible for funding the country's wind installations by taking advantage of federal tax credits and accelerated depreciation. As the crisis grew, the pool of available tax equity capital all but evaporated leaving projects starved for capital.

In Q1 2009, Congress approved ARRA, which included a new program allowing project developers to, in effect, take the roughly equivalent benefit of the tax credits in the form of cash grants. The '1603 program' as it has come to be known sustained the US clean energy sector through a particularly difficult period. It also disbursed taxpayers' funds to clean energy projects in a substantially more efficient and cost-effective manner than the tax credits did. It supported financings in 2010 that will result in project constructions in 2011 and 2012. The program is now due to start expiring at the end of 2011 and the Production Tax Credit sunsets end of 2012.

Wind installations in the US fell by half in 2010. Bloomberg New Energy Finance anticipates somewhat of a pick-up in development activity in 2011 with between 5.8GW and 7.3GW to be installed this year. We anticipate new installation activity to remain relatively flat from 2012 through 2014, barring a major change in natural gas prices or a major new policy shift. Our forecast of wind capacity growth in the US assumes 1603 expires as planned but the PTC is extended. If the PTC is not extended, the US will likely see a sharp drop in project installations.

Today, the market both globally and in the US is fundamentally over-supplied with wind turbines. On US soil in 2011 (Figure 5), we anticipate over 12GW of final turbine assembly capacity, far above what will be demanded domestically. This will likely compel manufacturers to export their equipment elsewhere, run their plants below capacity, or take them offline altogether.

It is for this reason that Chinese equipment makers are likely to have difficulty making significant inroads into the US market, at least in the short run. Thanks to over-supply, wind turbine prices have fallen from their highs of approximately $1.5m-$1.8m/MW to a current price of approximately $1m-$1.3m/MW. With equipment readily available from established Western companies with strong existing reputations in the US, market entry should prove challenging, at least for now.

By contrast, low-priced Chinese equipment has played an integral role in growth of the US PV sector, which has grown quite rapidly in the past three years, though off a very small installed base. In 2008, 342MW of new PV capacity was installed in the US. That jumped to more than 900MW in 2010 with over half of all installations coming in California and New Jersey, both of which have solar-specific subsidies in place.

Chinese PV equipment makers such as Suntech and Yingli played only a minor role n the US market less than four years ago. In California during the first three months of 2007, Chinese equipment accounted for 15% of all installations that requested rebates under that state's Solar Initiative (Figure 4, measured in terms of megawatts capacity). By the last quarter of 2010, Chinese equipment makers were the suppliers of choice on installations representing over half the megawatts to be installed. US-headquartered solar equipment makers such as SunPower and FirstSolar now account for a smaller share of what is now a much larger market.

Looking ahead, Bloomberg New Energy Finance anticipates strong growth in PV installation in the US with the market potentially doubling in 2011 to 1.8GW installed, then rising to 2.8GW in 2012. Still, the US market will remain relatively small when compared to Germany, Italy and Spain unless the federal government and/or states enact broader, more supportive policies.

1.3. The US-China clean energy trade relationship

Some have painted competition between the US and China on clean energy manufacturing and development in stark terms with China feared or admired as an exports winner and the US criticized or dismissed as a manufacturing also-ran. But the relationship between the nations defies simplistic assumptions defined by economic nationalism. Chinese PV modules are often manufactured using US-made equipment while US wind turbines regularly contain Chinese-made components. In this area as in so many others, China and the US are mutually dependent; each must rely at least in part on the other to achieve its clean energy and carbon reduction objectives.

For instance, as with most technology products, PV modules comprise a number of parts from all over the world. Figures 7 and 8 break down where the parts are manufactured for a hypothetical module from Suntech, a China-headquartered firm, and for SunPower, a California-headquartered company. Suntech procures polysilicon from producer MEMC of Missouri, while ingot, wafer and cells manufacturing take place in China. Suntech now does some final module assembly at a new facility in Arizona. In some cases, over half the economic value of the module manufacturing goes to the US. (However, it should be noted that Suntech still does most of its final assembly of modules in China).For SunPower, silicon comes from the US or South Korea, while wafers and cells are manufactured in the Philippines, and module assembly can take place in Mexico.

The US-China clean energy trade has proven to be a flashpoint between the two nations in light of a 2010 complaint filed with the United Steelworkers with the US Trade Representative. Concerns have been raised among US policymakers that Chinese policies have made it difficult for US clean energy equipment suppliers to compete in China.

Questions of fair trade aside, there can be little doubt that China's extraordinary entry into the clean energy marketplace has played a major role in driving down the overall cost of clean energy equipment. The country's support for the largest PV and wind equipment manufacturing plants the world has ever seen has allowed for unprecedented economies of scale and lower prices. As discussed above, solar is rapidly moving toward grid parity. This is in no small part due to the build-out in China and its extraordinary financial resources.

Finally, it should be noted that the faster clean energy equipment prices fall, the more quickly such equipment can be deployed into the field at costs competitive with conventional energy. This has major implications for job creation. Much of the 'green jobs' discussion to date has centered on manufacturing jobs. But clean energy can create significant employment opportunities at the final stages of the value chain as well. Bloomberg New Energy Finance calculates that for every megawatt of PV capacity installed on a residential rooftop, a total of 15.1 full-time workers are required. No less than 10.5 of them are involved in the final stages of installation, on average. By contrast, manufacturing accounts for just under one-third of the total employment per megawatt of new capacity.

2. THE 'VALLEY OF DEATH' CONUNDRUM

Thanks to a massive investment surge, clean energy technologies have made exceptional progress down their respective learning curves in recent years. Still, much work remains; the cost of generating a clean kilowatt-hour is still generally above that of generating one from coal or natural gas on an unsubsidized basis, assuming no associated costs are assessed for carbon pollution. One of the biggest impediments to further progress is a persistent dearth of capital for potentially lower-cost breakthrough technologies that have advanced out of the laboratory but still require extensive and expensive field testing and trial installations before being deployed at scale. Financing has existed in the past for early stage, potentially high-risk/high-return technologies in the form of venture capital. It is also available for late stage, potentially low-risk/low-return technologies in the form of project financing. But what about those technologies that fall somewhere in between?

As the old adage among entrepreneurs goes, 'banks will always be the first in line to finance your second project'. This so-called commercialization 'Valley of Death'—located somewhere between Silicon Valley VCs and Wall Street banks—poses a long-standing challenge to the clean energy sector, just as it has to other capital-intensive industries in the past. Bridging this gap is critically important; existing technologies have an important role to play but costs must come down further.

Today, there are in effect two valleys for clean energy technologies. The first comes at the very earliest stage when the potential commercial applicability of a technology remains unclear. The later, better-known valley takes place as a new technology looks to scale up. The tends to occur somewhere toward the end rounds of venture capital investment.

In response to this conundrum, Congress in 2005 established a loan guarantee program intended to help bridge this gap. The program offered its first guarantee in 2009 and has served as something of a lightning rod in recent months. Developers and investors regularly complain that the application process for loans guarantees is confusing, difficult to navigate, and far too costly and time-consuming. Meanwhile, some in Congress have expressed concern that DOE has cut corners while conducting due diligence on potential guarantee recipients. In essence, industry is frustrated that DOE has moved too slowly while Congress has complained that it has moved too fast.

In our view, the loan guarantee program puts the federal government in a fundamentally awkward position. On the one hand, it has been charged with helping to finance potentially game-changing technologies. On the other, it must serve as a careful guardian of taxpayer funds. As private sector investors know well, investing in new technologies inevitably involves a high degree of risk. We believe the loan guarantee program can foster important breakthroughs, but will also inevitably result in some number of failures. If the federal government is going to guarantee financing for technologies, it must also be comfortable with the inherent potential downsides. As any serious investor in stocks, bonds, or other securities knows, having a portfolio of both winners and losers is inevitably part of the game. Success is determined by the portfolio's overall performance.

The loan guarantee program aside, the fundamental challenge of the valley of death remains for many new companies seeking to build their first pilot-scale project. From a larger strategic point of view, we would argue that whichever nation puts in place policies or financing schemes to bridge this gap stands to reap the greatest economic benefit in the long haul.

The CHAIRMAN. Thank you very much.

Ms. Gallagher, please go right ahead.

STATEMENT OF KELLY SIMS GALLAGHER, ASSOCIATE PROFESSOR OF ENERGY AND ENVIRONMENTAL POLICY, DIRECTOR, ENERGY, CLIMATE, AND INNOVATION PROGRAM, THE FLETCHER SCHOOL, TUFTS UNIVERSITY, MEDFORD, MA

Ms. GALLAGHER. Chairman Bingaman, Senator Murkowski and other members of the committee, thank you very much for inviting me to come here today.

Let me start with 3 basic points.

First, in my view the United States is undoubtedly a leader in clean energy innovation in many dimensions. Other countries like Germany, Denmark, Iceland, Brazil, the United Kingdom and Japan have also become leaders in clean and efficient energy technologies and industries. We also have new contenders most notably China that have recently emerged as well.

In order for the United States to remain competitive in clean energy it must strengthen its energy innovation system and ensure that's firms are not operating at a disadvantage in the global marketplace. As my testimony will reveal U.S. strategies, policies and investment for clean energy innovation are significantly different from the efforts of many of our competitors in clean energy. I do believe we could do better.

The United States needs to set clear and measureable goals. Determine and articulate strategies to achieve these goals. Then implement practical energy policies that are stable, credible, aligned and consistent to realize the deep and currently unrivaled potential of the U.S. energy innovation system. Such policies are likely to catalyze the creation of new firms, strengthen others, generate new jobs, capture growing markets, improve energy security and address important environmental challenges as they have in other countries.

Let me give you a few examples.

Denmark has achieved remarkable success in the development and deployment of wind technology which now accounts for 20 percent of electricity generation there through a mixture of many policy instruments. At the Danish wind farm, Vestas, or wind firm, Vestas, has a 13 percent market share of the global wind market which the largest of any single firm.

Like Denmark, Germany established renewable targets far into the future, 18 percent by 2020 and 50 percent by 2050. Germany accounts now for nearly half of solar PV capacity today. Its firms are leading renewable equipment suppliers around the world.

Indeed during one visit to a solar PV factory that I made last summer, I noticed that many of the manufacturing equipment came from Germany and Japan. Was startled to discover many dozens of Germans in the company cafeteria at lunch time, all of whom were there to install equipment in the new assembly line. German feed-in tariffs created market demand upon which solar, Chinese solar PV firms have capitalized based on equipment sold to them by German equipment suppliers.

The UK government created a renewables obligation similar to renewable portfolio standard in 2002. This standard is scheduled to ramp up through 2037. It's also imposed a climate change levy and established the carbon trust which provides zero interest loans to firms, tax relief, energy management advice, certification labels and direct support for advanced technology in firms.

As you know Brazil is well known for improving its energy security and de-carbonizing its transportation system through their development of a sugar cane based ethanol beginning in 1975. It's now the largest ethanol exporter in the world.

China recently codified its commitment to support a low carbon energy efficient growth strategy in its 12th Five Year Plan. It has 2, a renewable portfolio standard which has been revised to 15 percent by 2020. It's established feed-in tariffs for wind.

It's supported the deployment of high efficiency, ultra super critical coal. Approved the construction of GreenGen, which is an integrated gasification combined cycle coal plant capable of capturing and storing CO_2. This plant is now anticipated to be in operation well before the U.S. equivalent FutureGen.

China has extensive procurement policies that are used to encourage the development of clean and efficient energy technologies. It ensures that its firms have relatively easy access to finance on quite favorable terms. Chinese firms now hold 23 percent of the global market in solar PV manufacturing and 23 percent of the wind market, wind turbine manufacturing market.

The topic for today is current investment trends in clean energy. I'd like to present some findings from a recent paper with colleagues on trends in public investments in energy research development and demonstration. These are—include clean energy investments but are not limited to clean energy.

In this paper we found that 6 major emerging economies, Brazil, Russia, India, Mexico, China and South Africa, are investing slightly more than all of the OECD countries combined. These BRIMCS countries, as we call them, spent $13.8 billion in 2008 compared with the OECD total of $12.7 billion for a global total of $26.5 billion that year. For reference the U.S. total in that year was $4.1 billion.

Japan and more recently China are the only 2 countries that have historically, steadily increased their investments in real terms. By contrast in the United States there's been a 1 in 3 chance that any given program will receive a funding change, ei-

ther an increase or a decrease, greater than 27 percent each year between 1978 and 2009.

So to sum up here. Ideally the U.S. Government will adopt a portfolio approach to investing in clean energy technologies taking into account the different stages of technology deployment. Which technologies are likely to be substitutes or complements to existing technologies and knowledge about the private sector investments to avoid duplication of effort and to better design public/private partnerships?

Of course it is also critical to take into account the investments made by other governments. Not only to understand the competition per say and to determine one's strategic interests, but also to identify potential areas for technology cooperation. The United States must therefore carefully monitor investment trends and policy developments in other countries as they will strongly affect market conditions for U.S. firms and workers.

Thank you.

[The prepared statement of Ms. Gallagher follows:]

PREPARED STATEMENT OF KELLY SIMS GALLAGHER, ASSOCIATE PROFESSOR OF ENERGY AND ENVIRONMENTAL POLICY, DIRECTOR, ENERGY, CLIMATE, AND INNOVATION PROGRAM, THE FLETCHER SCHOOL, TUFTS UNIVERSITY, MEDFORD, MA

SUMMARY

Chairman Bingaman, Senator Murkowski, and other members of the Committee, thank you very much for inviting me to testify before you today on the topic of global investment trends in clean energy technologies[1], and the impact of domestic policies on that investment. I am Kelly Sims Gallagher, a professor of energy and environmental policy at The Fletcher School, at Tufts University. I direct our program on Energy, Climate, and Innovation, and concurrently serve as a Senior Research Associate at the Belfer Center in the Harvard Kennedy School. I served as a Visiting Professor at Tsinghua University's School of Public Policy and Management last summer where I conducted research on global energy commercialization, with emphasis on the role of China.

The United States is undoubtedly a leader in clean energy innovation in many dimensions. Other countries like Germany, Denmark, Iceland, Brazil, the United Kingdom, and Japan have also become leaders in clean and efficient energy technologies and industries. New contenders, most notably China, have recently emerged as well.

In order for the United States to remain competitive in clean energy, it must strengthen its energy innovation system, and ensure its firms are not operating at a competitive disadvantage in the global marketplace. As my testimony will reveal, U.S. strategies, policies, and investments for clean energy innovation are significantly different from the efforts of many of our major competitors in clean energy technologies, and I believe we could do better.

The United States needs to set clear and measurable goals, determine and articulate strategies to achieve these goals, and then implement practical energy policies that are stable, credible, aligned, and consistent to realize the deep and currently unrivaled potential of the U.S. energy innovation system. Such policies are likely to catalyze the creation of new firms, strengthen others, generate new jobs, capture growing markets, improve energy security, and address important environmental challenges, as they have in other countries.

What do we know about how energy innovation works?

Research and development (R&D) is often used as shorthand for energy innovation. But, research and development are only one component of the energy innovation system (see Appendix A for a visual depiction of the energy innovation system). In the linear growth model of innovation, we used to think technologies were in-

[1] I define "clean energy technologies" to include solar, wind, nuclear, energy efficiency technologies, coal with carbon capture and storage, geothermal, and hydroelectric electricity. None of these technologies is without liability, but all can be considered cleaner than conventional fossil-fuel based alternatives.

vented in the R&D stage, before they proceeded to demonstration, and eventually were "diffused" in the marketplace. This model is still a useful one to consider, but I would emphasize that the diffusion "stage" is not so simple. If and when a new technology is successfully demonstrated, it must somehow gain entry into the market, and this can be difficult because:

- New technologies are unfamiliar and seemingly risky,
- They are often initially more expensive,
- They usually do not have equivalent government support, and,
- The incumbents will try to prevent them from entering.

Clean and efficient energy technologies face an even bigger hurdle because their benefits are not fully valued by the market. In other words, even though they may offer significant advantages in terms of reduced pollution, improved public health, or greater energy security, the market will not naturally reward these advantages. We can see, then, that there is an important intermediate stage between demonstration and diffusion that is "market formation." In the market formation stage, government can help to reduce the barriers to cleaner technologies (and indeed, these can be barriers once created by governments), provide niche markets, and incentivize firms to reduce the costs of advanced technologies. Once a technology is sufficiently competitive, it can freely enjoy widespread commercial diffusion.

While the linear model is helpful conceptually, we now know that there needs to be coherence to the entire system, encouragement of feedbacks, with a balance of effort on "pushing" and "pulling" new technologies into the market. We know that there are at least two important "valleys of death", one between R&D and demonstration, and another between demonstration and commercialization.[2]

How does the United States compare?

Around the world, governments are engaged in substantial market formation activities, some more successfully than others. I will provide some examples.

Denmark has achieved its remarkable success in the development and deployment of wind technology (now 20% of electricity generation) through a mixture of many policy instruments. It established a goal for wind generation, required utilities to achieve the goal, permitted the formation of local co-ops to own and operate turbines of many sizes, provided testing stations and certification, established a feed-in tariff for wind, guaranteed loans for turbine exporters, and joined the EU emissions-trading regime. Denmark now has established a more far-reaching goal of 50 percent of generation. Danish wind firm, Vestas has a 13% market share of the global wind market, the largest of any single firm.[3]

Like Denmark, Germany participates in the EU emissions trading regime. It established renewables targets far into the future 18% by 2020 and 50% by 2050. It also established a feed-in tariff system for renewable energy technologies, which guaranteed a price at which renewables would be bought for a certain period of time. While this program proved to be expensive, it was also effective. Germany accounts for nearly half of solar PV capacity today.

Its firms are leading renewable equipment suppliers around the world. Indeed, during one visit to a Chinese solar PV factory last summer, I noticed that most of the manufacturing equipment came from Germany and Japan, and was startled to discover dozens of German technicians in the company cafeteria at lunch, all of whom were there to install their equipment in the new assembly line. German feed-in tariffs created market demand upon which Chinese solar PV firms capitalized, based on equipment sold to them by German equipment suppliers.[4]

The UK government created a renewables obligation, similar to a renewable portfolio standard in 2002. This standard was initially set at 3 percent and is scheduled to ramp up through 2037. The current obligation is 11 percent. The UK also imposed a climate change levy in 2001, which taxes fossil fuels and nuclear energy. The British government also created the Carbon Trust in 2001. This not-for-profit organization provides services to firms and local governments including zero-interest loans, tax relief, energy management advice, certification labels, educational materials, and direct support for advanced technology development in firms.

Brazil is well known for improving its energy security and decarbonizing its transportation system by shifting to sugarcane-based ethanol beginning in 1975. This shift was achieved through the combination of many policy measures, including

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[2] Grubler A., Aguayo F., Gallagher K.S., Hekkert M., Jiang, K., Mytelka L., Neij L., Nemet G., Wilson C. 2011, "Energy Technology Innovation Systems," in, Nakicenovic et al., eds., The Global Energy Assessment, Cambridge University Press.

[3] REN21. 2010. Renewables 2010 Global Status Report, Paris: REN21 Secretariat.

[4] Ibid.

guaranteed purchases by Petrobras, taxing gasoline to make ethanol more attractive at the pump to consumers, mandates to achieve a certain percentage of its fuel from ethanol, and low-interest loans for farmers and agribusinesses to produce sugarcane. Brazil is the largest ethanol exporter in the world.

China recently codified its commitment to support a low-carbon, energy-efficient growth strategy in its 12th Five Year Plan. The plan sets clear goals adding 70 gigawatts of additional wind generation capacity and 40 additional gigawatts of new nuclear power by 2015, sending strong positive signals to investors in low-carbon energy. China also had a renewable portfolio standard of 10% by 2010, which has been revised to 15% by 2020. It has established feed-in tariffs for wind energy. It has supported the deployment of high-efficiency ultra-supercritical coal plants, and approved the construction of GreenGen, an integrated gasification combined cycle plant capable of capturing and storing carbon dioxide, which is now anticipated to be in operation well before the U.S. equivalent, FutureGen. The Chinese government set fuelefficiency standards more stringent than even the most recent U.S. corporate average fueleconomy standards for its motor vehicle fleet. Extensive procurement policies are used to encourage the development of clean and efficient energy technologies, and it ensures that capable clean tech firms have relatively easy access to finance on favorable terms.[5] Chinese firms now hold 23% of the global market in solar PV, and 23% of the global wind market.

The policies of these countries are far from perfect, but there is much to be learned from their and our experience experimenting with different types of policies, over different time horizons, in different places. Common features include the setting of long-term goals, establishment of stable and credible policies that are aligned to achieve the goals, provision of consistent signals to the marketplace, and support of firms.

The topic for today is current investment trends in clean energy technologies, and findings from a recent paper with colleagues on global trends in government investments in energy research, development, and demonstration (RD&D) are striking.[6] This analysis includes all public investments in energy innovation (including, but not limited to, investments in clean energy technologies). We found that six major emerging economies are together are investing slightly more than all of the OECD countries combined (see Appendix B for a table with countryby-country breakdowns). The six countries studied were Brazil, Russia, India, Mexico, China, and South Africa (BRIMCS). These BRIMCS countries spent $13.8 billion in 2008 compared with the OECD total of $12.7 billion for a global total of approximately $26.5 billion that year. I note that these BRIMCS figures include state-owned enterprise investments in these BRIMCS countries, and are adjusted for purchasing power parity. For reference, the U.S. total was $4.1 billion in 2008. The line between public and private investments in energy innovation in these countries is hard to draw due to the dominance of state-owned energy companies. The data underlying these figures is not standardized or complete; rather, this picture of current investment levels should be considered a rough sketch. As an important aside, it would be wise to expand the International Energy Agency's data collection efforts to include these BRIMCS countries so more accurate statistics are available.

The volatility of investments in both industrialized and developing countries is striking. Within the OECD, nuclear fission and fusion RD&D have been the single largest type of investment since 1974. Japan, and more recently China, are the only two countries that have historically steadily increased their investments in real terms. By contrast, in the United States, there has been a one-in-three chance that any given program will receive a funding change (increase or decrease) greater than 27% each year between 1978 and 2009.[7] Sharp jumps and declines in energy RD&D funding are also evident in Brazil, India, and Mexico. Like energy RD&D in the United States and other OECD countries, BRIMCS country energy RD&D appears to mainly be devoted to fossil fuel and nuclear technologies. In general, the large emerging economies appear to be ramping up support for energy RD&D, with the exception of Mexico. It was not possible to complete a similar survey of market formation and other deployment activities due to the lack of systematic and long-term data, even in industrialized countries.

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[5] For more on this subject, see Hout, T. and P. Ghemawat 2010, "China vs. the World: Who's Technology Is It?," Harvard Business Review, December.

[6] Gallagher, K.S., Anadon, L.D., Kempener, R. and C. Wilson 2011, "Trends in investments in global energy research, development, and demonstration," Wiley Interdisciplinary Reviews: Climate Change, Vol. 1, in press.

[7] Narayanamurti, V., L. D. Anadon, and A. D. Sagar 2009, "Institutions for Energy Innovation: A Transformational Challenge." Paper, Energy Technology Innovation Policy research group, Belfer Center for Science and International Affairs, Harvard Kennedy School, September.

A related important question is how successful the United States currently is in penetrating global markets for clean and efficient energy technologies through trade, licensing, and foreign direct investment. I believe other witnesses will address this issue, but I want to note that the largest energy market is now China, which became the largest consumer of energy last year. The International Energy Agency's 2010 World Energy Outlook forecasts that 36% of the growth in energy demand for the next two decades will be from China. As such, China is a key export opportunity for American energy products and services. Expanding access to China's market for energy goods and services should therefore be a major concern for the U.S. government.

In terms of the market for clean energy, HSBC has projected that the global clean energy market will triple to $2.2 trillion by 2020.[8] Such figures depend greatly on whether or not governments around the world put create the incentives for clean energy technologies to be used, so again, we should be doing all we can to secure a competitive position for U.S. firms to take advantage of opportunities in these markets.

The global trends I presented here are intended to support your decision-making about U.S. government investments in clean and efficient energy technologies and industries, and the policy tools that can be employed to create incentives for more rapid and greater deployment of advanced energy technologies. Ideally, the U.S. government will adopt a portfolio approach to investing in energy technologies, taking into account the different stages of technology development, which technologies are likely to be substitutes or complements to existing technologies, and knowledge about private-sector investments to avoid duplication of effort and to better design public-private partnerships. Of course, it is also critical to take into account the investments made by other governments, not only to understand the "competition" and determine one's strategic interests, but also to identify potential areas for technology cooperation. In theory, governments might be able to better pool resources and share risks in pre-commercial collaborative activities, as well as learn from each other's endeavors. Policy support during the market formation stages can strongly affect energy markets around the world, and in turn, energy RD&D needs. The United States must therefore carefully monitor investment trends and policy developments in other countries, as they will strongly affect market conditions for U.S. firms and workers.

The CHAIRMAN. Thank you very much.

Mr. Coleman, go right ahead.

STATEMENT OF WILL COLEMAN, PARTNER, MOHR DAVIDOW VENTURES, MENLO PARK, CA

Mr. COLEMAN. Mr. Chairman, Senator Murkowski and distinguished members of the panel, I appreciate the opportunity to be here today.

As mentioned I am a partner at the venture capital firm, Mohr Davidow Ventures. Since 1983 we've been investing in early stage technologies. We were one of the first mainline venture funds to start investing in the clean energy space. We've experienced the challenges associated with building successful businesses in the clean energy space. As always is the case in venture capital, we've also had our share of unsuccessful ones.

As venture investors we sit on the front lines of the innovation process. While we continue to see enormous opportunities to invest in the clean energy sector, in many key sectors as a Nation we are falling behind. I do think this should concern us.

First, because clean energy is one of the largest opportunities of the 21st century. The IEA predicts that $5.7 trillion will be deployed in the next 2 decades to clean energy.

But second and more importantly, our ability to lead on clean energy is critical to our competitiveness as a Nation going forward.

[8] HSBC 2010, "Sizing the climate economy", available for download from http://www.research.hsbc.com/midas/Res/RDV?ao=20&key=wU4BbdyRmz&n=276049.PDF

I think our dependence on unsecure and unaffordable conventional energy supplies is not just an energy problem, it's an economic problem. In 2010 we paid $337 billion to foreign countries for oil imports. That's money that could have been reinvested here in the U.S., in U.S. businesses and jobs. We'll spend $72 million just in the time it takes to have this hearing.

Solving this problem would cut our trade deficit by almost half. So while I know we are focused on cutting budgets and deficits. We should be clear that proactively solving this problem could do as much as anything to strengthen our economy.

Countries like China, India and Brazil, as mentioned, recognize the opportunity. China has already committed $738 billion to clean energy over the next 10 years. They're investing because they intend to leap frog the U.S. in these technologies like they did in high technology manufacturing and wireless communications among others.

Now I'm not suggesting that the U.S. Government should try to outspend the Chinese government. But I absolutely believe that the private sector can out invest and out compete the Chinese government if given the right policies. Unfortunately here in the U.S. we have 2 major impediments to private investment in next generation energy technologies.

First, many energy markets are very difficult to penetrate because they are heavily regulated and dominated by incumbents. Let me give you an example. A couple of weeks ago I saw a technology that would have made the grid more stable, easier to manage and lower cost. The technology had been tested. But when I spoke to the grid automation engineers inside the utility they described a 5 to 10 year process for piloting the technology.

At that point they imagined a classic hockey stick adoption curve. But the problem is it takes too long to get there. So I think the challenge is is that with any new entrant they need to go through the utilities and a patchwork of 50 different public utility commissions, none of whom have an incentive to take technology risk. So without a national policy aimed at adoption it is very hard for investors, like us, to invest and innovation tends to dry up.

The fuels market is similar except the problem there is that it is dominated by vertically integrated incumbents. To enter the market a new technology must go through these incumbents who tend to control the channels or reinvent the entire supply chain. This raises the second impediment which is that most new technologies need to get to commercial scale to compete.

Solar is a great example of what can happen if you get there. First Solar, a leading American solar company, unlocked huge reductions in cost just through its novel approach, but they were able to reduce their panel production costs from over $3 a watt in 2004 to under 80 cents a watt today. That was largely because they ran production 2,500 percent over the same time period.

At these costs they are already competitive with many combined cycle gas plants. That's part of the reason why First Solar is now more valuable as a company than every U.S. coal company except for one. First Solar is a great story, but it was largely possible because they had a unique set of very patient investors and an open market.

In many strategic markets the private financing needed to scale new technology remains on the sidelines. If markets were open and accessible some equity investors would flow in. But when markets are tough to enter equity investors are hard to come by.

The good news for America is that our scientists and our entrepreneurs are still churning out great ideas and innovative companies. We have a robust national lab system, some of the best university labs in the world which we interact with on a regular basis and leverage able private markets. As venture investors we see plenty of opportunities around clean energy. We don't need hand outs, but we also won't invest in certain strategic areas unless the market conditions change.

The solutions need not be complex or expensive.

First, we need policies that create long term targets and transparent criteria like a clean energy standard or an open vehicle standard. These would open markets for new entrants and let them compete in the marketplace.

For those sectors where the financing gaps are most pronounced we need support for innovative technologies to get through the commercial demonstration gap. These need to be performance driven. They need to rely on the market to dictate winners and losers. Most importantly, prioritize innovation which means the government needs to be tolerant of taking some level of risk. We have seen some programs deployed through the DOE and the USDA as mentioned. But there are other proposals some of which this committee has proposed, that would go much further.

So in conclusion, let me just say that we are behind. In PV and wind we have seeded the lead to China in just a few years. If we don't move forward urgently I'm concerned that we will not only seed the current opportunity but we'll lose the knowledge and the experience necessary to compete going forward.

The question is whether America builds the next generation of energy technologies here that will be the bedrock for our competitive economics over the coming century. If we act now we can do this. I think we will prosper as a result.

Thank you for your time and attention here today. I look forward to questions.

[The prepared statement of Mr. Coleman follows:]

PREPARED STATEMENT OF WILL COLEMAN, PARTNER, MOHR DAVIDOW VENTURES, MENLO PARK, CA

INTRODUCTION

Thank you Mr. Chairman, Senator Murkowski and distinguished members of the Committee. I appreciate the opportunity to be here today. It is an honor and a privilege to speak with you on an issue that is so critical to our nation.

I am Will Coleman, a partner at the venture capital firm Mohr Davidow. We invest in early stage companies on behalf of some of the largest endowments, foundations, and families in America. Since 1983, we have funded over 250 companies, helping entrepreneurs transform new ideas into thriving businesses and create new jobs in information technology, life sciences, and energy.

We were one of the first mainline funds to move into energy and have since invested in a range of sectors including solar, biochemicals, coal gasification, transportation, and battery materials, among others. So we have had the opportunity to experience the challenges of building successful businesses in these segments.

I'm here today to talk about some of those challenges, but I also want to start with a premise. Clean energy may well be the largest opportunity of the coming cen-

tury. But more importantly, taking a lead on the next generation of energy technologies is absolutely critical to our continued competitiveness as a nation.

Unfortunately, on both fronts we are falling behind.

AMERICAN COMPETITIVENESS REQUIRES NEXT-GENERATION ENERGY SOLUTIONS

As venture investors, we sit at the front edge of innovation in this country. Globally we are seeing investment in clean technology continue to grow. In 2010, $7.8 billion was invested by venture capitalists into clean tech companies and over $127 billion was invested globally in renewable energy project financing. The International Energy Agency (IEA) forecasts that over $5.7 trillion will be invested in renewable energy globally over the next two decades. Unfortunately it is looking less and less likely that investment will be here in the U.S. We are not only seeing companies start here in the U.S. and then move overseas, but we are increasingly seeing companies start overseas and stay overseas.

As Americans, we pride ourselves on our ingenuity and our pioneering nature. Our greatest strength is our ability to take on great challenges, and to lead the world in transformations that have impacted every facet of our lives. In the past, we've embraced change and we have prospered as a result. As Americans we take risks.

However, in energy we seem to fear change, and it is paralyzing us. I am concerned that if we don't work to develop the next generation of solutions here in the U.S. we will lose the capability and know how to innovate in these sectors in the future.

Why is this a problem? The single biggest challenge we now face as a nation is our dependence on unsecure, unsustainable, and unaffordable conventional energy supplies.

In 2010 we paid $337 billion to foreign countries for oil imports; stated differently, we transferred $337 billion of America's wealth—that could have been reinvested in businesses and jobs in the U.S.—to oil-exporting countries. That represents over 42 percent of our trade deficit—42 percent! The number will be even higher in 2011. In the time it takes to have this hearing we will have paid $36 million for foreign oil—and that's only direct spending. So while we talk about reviving our economy and cutting deficits, the single largest cost to our economy is our dependence on oil.

And I say "oil," not just "foreign oil," for a reason. The issue is not oil itself. It's that it is a global commodity. Although domestic exploration may provide important security and economic benefits in the short term, we don't have the domestic capacity to offset the long-term trend of rising global demand. In essence, we lack a portfolio approach or a hedging strategy, which could cushion us from the most severe commodity price swings.

That means, American families and businesses will remain at the mercy of global energy prices. The oil price shocks of 1973-74, the late 1970s and early 1980s, the early 1990's, and 2008 were all followed by recessions (EIA). As long as we don't have alternatives we cannot avoid the price swings.

Our dependence on oil is not just an energy problem. It is an economic problem. Our biggest competitors recognize the opportunity and are seizing leadership positions with the clear goal of out-competing an increasingly dependent and out-dated America.

China, India, and Brazil are increasingly focused on developing and deploying the next generation of energy technologies. China is now the number one global producer of photovoltaic solar cells. They were barely on the map a few years ago in solar production. Just last week, Suntech, a Chinese solar manufacturing company overtook America's leading solar manufacturer, First Solar, as the world's largest producer of solar modules. This emergence of Chinese manufacturing certainly has something to do with the $22.5 billion in low cost loans that the Chinese government provided to five domestic solar producers in Q2-Q3 2010. However, they are also heavily focused on nuclear and now coal gasification and have recently stepped up their engagement with American startups to deploy leading edge technologies in China instead of the United States. China is the world leader in installed hydro power capacity and overtook the United States in 2010 for the number one ranking in installed wind power capacity, too.

Over the past few years, China has committed to clean energy deployment targets that dwarf the U.S. commitment and last year announced plans to spend as much as $738 billion through 2020 to reach those targets.

Some people would argue that we cannot afford to outspend the Chinese in this effort, and we all know you don't want to bring a knife to a gunfight. I would not argue that our government should try to outspend theirs, but I can't accept the premise that we should concede anything. Our economy is still more than two times

larger than China's with one quarter the population. I absolutely believe that the U.S. private sector can out-innovate and out-invest the Chinese government.

We won the Cold War in large part by outspending the Soviets. We can't let our competitors do the same thing to us in the energy race. Instead of letting capital flee to China, India and Brazil, we need to create the investing climate that draws our own private capital stocks into the market and draws foreign capital flows here into the U.S. We can create such a climate without massive government spending, but we do need government action and support.

CHALLENGES OF INVESTING IN U.S. ENERGY MARKETS

Few people in this room today would challenge the notion that America's commitment to free market principles has played a key—if not decisive—role in building our global economic leadership. The venture industry is predicated on belief in the power of the private market to generate and adopt better technologies.

I am not here today asking for help. We as venture capital investors have plenty of opportunity to invest in energy and clean technology models that fit our return needs. That said, we see a number of obstacles in certain segments. As a result of these obstacles, there are specific industries and segments where private investors can't or won't go today, and there are others where investors will only go selectively. These are often the most strategically important industries for our nation's future. We must resolve these obstacles to remain competitive.

OBSTACLES TO TECHNOLOGY ADOPTION

First, the U.S. does not have an innovation problem, but rather, we have an "innovation adoption" problem. Most energy markets are either a) heavily regulated or b) dominated by incumbents. In either case, markets are extremely hard to enter for a new player.

And in the case of electricity markets we actually have both. The patchwork of state and federal regulations is incredibly challenging to navigate for any company—let alone a fledgling startup. The only path to market is often through utilities and public utility commissions, both of which have incredibly low tolerances for risk. Market entry for any new technology, particularly on the grid side, can take 5 to 10 years of piloting and small deployments before a single state is ready to deploy that technology broadly. This timeframe eliminates a whole category of technologies for venture investors who need to see rapid growth much more quickly to make the investing model work.

In the fuels and chemicals industries, transportation, and other industrial segments, the primary challenge for new entrants is that the incumbents are often vertically integrated, own the channels, and have a history of sharing IP. In many cases, profits depend more on collaboration than competition. To enter the market, a new technology must go through these incumbents or re-invent the entire supply chain. Unless incumbents believe that that these new entrants can build large stand-alone companies—in other words, pose a credible threat to their businesses—then the incumbents have little incentive to adopt new technologies.

Without these incentives, incumbents are unlikely to pay premiums for new technology and we won't see the value creation necessary to propel new public offerings or acquisitions. In the absence of valuable exits, equity investors will not invest upstream in the technology development necessary to prove out the technology. We see a reverse domino effect and the innovation pipeline in those segments dries up—which means that a whole set of improvements may never make it to market.

FINANCING GAPS

The second obstacle is that even in markets which are free and open there are often financing gaps that can prevent new technologies from getting to market. Incumbent companies benefit from decades of investment in infrastructure, legacy government support, fully depreciated plants, economies of scale and operating track records that afford access to low-cost capital.

My firm recently sold one of the companies in our portfolio to Sharp—partly because the cost of the working capital required to grow the company would have been much higher had we secured it through private sources rather than through Sharp's balance sheet. The only path to rapid growth was through a major corporate partner.

For startups, getting to cost competitiveness typically requires getting to scale. As with any new product, particularly an industrial or commodity product, part of the cost reduction comes from technological innovation and part of it comes from economies of scale. But this can be a Catch-22. Many people argue that the new alternative energy technologies are not competitive so we shouldn't support them, and

if they were competitive then we wouldn't need to. But that misses the point. The question isn't where they are on the cost curve today; the question is whether their costs will ultimately get below existing options. That is what makes them worth investing in.

All one has to do is look at the solar cost curves to see how this works. Over the past thirty years, solar manufacturers have made significant improvements in cost with every generation of new technology—but the real cost reductions have been primarily when they scaled production. For example, First Solar's panel production costs have dropped from over $3.00/watt in 2004 to under $0.80/watt today, due in large part to a 2,500% increase in production capacity from 2004-2008. And costs continue to drop. That is part of the reason why First Solar is now more valuable as a company than every U.S. coal company except one. Fortunately, we have a company we hope will get even lower.

The challenge for most startups is that without operating track records, they are unable to leverage low-cost capital to get there. This means that they typically need to raise higher-cost equity or some combination of equity, mezzanine financing (if available), and debt (which often isn't available) to build early commercial plants.

Again, this triggers the reverse domino effect. If we as early stage investors don't anticipate low cost capital being available to scale these technologies, then there is no way we will invest in the early technology development in the first place.

POLICIES DON'T SUPPORT STARTUPS

The third obstacle is that where we do have incentives and tax credits to support new technologies, many of them are not designed for small emerging companies. Startups do not have the balance sheets or track records that larger corporations do and have trouble securing and monetizing the credits, incentives, and loans that have been made available. As a result, it forces startups to either construct some mix of unnatural third-party relationships or go to market through the big incumbents, which can have dramatic impact on their value and investor interest.

If time didn't matter, if we were not in a race to remain competitive in the global economy, if the private market valued our national security, the domesticity of our products, and the health and environmental impacts, then ideally we would let the market work to adopt the best solutions. Unfortunately, time does matter and the market does not value these national strategic interests. For these reasons, whether we like it or not, our government must play a proactive role in encouraging clean energy development.Accelerating the Adoption of Clean Energy

The good news for America is that our scientists and entrepreneurs are still churning out innovative clean technology ideas and companies. We have a robust national lab system, which I have had the opportunity to work with as an advisor to the National Renewable Energy Lab. And we have some of the best university research labs in the world. We also have a robust private capital ecosystem that has growing experience in energy and clean technology. In 2010, the venture capital industry invested more than $3.6 billion into clean technology companies, which is second only to information technology. If the history of venture capital is any guide, then those dollars can generate ten times the investment downstream. The challenge is how to draw the necessary investors into the segments that represent heavier capital lifts and riskier market entry.

Fortunately, there are several ways in which the U.S can unleash a wave of private sector investment and promote innovation at the same time. Government can do this without "picking winners" and without huge costs to the taxpayer.

1) Improve market access and demand

It all starts with demand. Where there are large, open markets that can be captured by better performing technologies, you will see investors, and you will see the development of a manufacturing base. Germany accomplished this with a robust Feed-In-Tariff, which attracted most of the top solar companies to build manufacturing facilities inside the country. First Solar began as an American company but moved to Germany to be close to the market.

Similarly, the Chinese have aggressive five-year plans that make it clear which segments will reward investment. These policies are easy to invest ahead of.

Here in the U.S., we have a patchwork of state renewable portfolio standards and programs. While these programs have supported the development of renewable energy in those states, we lack the kind of nationally unified strategy that would create more attractive opportunities and provide long-term signals to investors. We need to implement a set of national standards for electricity and transportation. Programs like a Clean Energy Standard and an Open Vehicle Standard are the simplest market based approaches. They would push incumbents to adopt new technologies more rapidly and give investors the incentives to take larger capital risks.

2) Fill the financing gaps

For those segments that have high strategic value to our nation, but do not attract private investment, we need a set of tools to help fill the financing gaps and draw private capital in. These tools should prioritize innovative technologies, and they need to be flexible, efficient, and technology neutral. Above all else, they must be predictable. Investors need to know that if a company builds a technology that achieves a specified level of performance, they will be able to access these tools to help finance them to scale.

The primary financing gap typically occurs where a company must scale up to a demonstration facility or first commercial plant. We've seen this in solar manufacturing facilities, biofuel plants, battery production lines and a host of other technologies. The capital requirements tend to outstrip the capacity of most equity investors that are willing to tolerate technology risk. Without an operating track record, debt is difficult to secure. We have already seen a mix of government solutions, ranging from grants to loans that target this gap. These are helpful but not complete. The solution need not be only direct spending or billion-dollar governmentfunded demonstration projects. There are existing classes of capital that could be drawn in to fill these funding gaps—venture debt, mezzanine funds and other lenders—but they need some inducements to come into these sectors. The legislation co-sponsored by the Chairman and Ranking Member Murkowski in the last Congress to create the Clean Energy Deployment Administration is targeted to solve this problem.

The bottom line is that if we are serious about filling these gaps in sectors that have high strategic value to our nation, then government needs the capacity and flexibility to provide a mix of different structures and adapt these structures over time to evolve with the market.

3) Replenish the innovation pipeline

Thirdly, we need to make sure we continue to replenish the innovation pipeline. We cannot starve the research budgets that not only breed the next generation of innovation, but keep the talent here in the U.S. I recently met with a professor who had started a battery company in California. He had immigrated to the United States from Vietnam to go to school here and stayed to become a professor. We had seeded his research and other U.S. venture investors had backed the startup. He had just returned from a trip to China and he was worried about our ability as a country to keep pace with the Chinese. I could see in his eyes that he desperately and earnestly wanted to build his company here. This is where he and his team wanted to be, but he didn't think he could pass up not only the financial support that the Chinese were throwing at him, but also the lab and research resources they would provide.

We have the talent, but we need a commercialization pathway that can continue to keep that talent here. That's why it is critical that Congress continue to support basic R&D at universities and labs, and fund the Advanced Research Projects Agency for Energy. ARPA-E was designed to spur exactly the type of early commercial research and development that our innovators and venture investors look for. ARPA-E is a small but critical program that has developed into a model program for how government should tackle these challenges.

4) Accelerate the adoption and deployment process

Finally, the U.S. must streamline the process by which energy and other clean technology companies obtain patents, permits, certification and authorization to manufacture and sell their products. In short, the pathway through the regulatory environment must be clear and predictable, and it must be manageable by large and small companies alike. Right now it is not. We need to show companies that America is open for business.

One of the biggest solar projects in the country nearly died three different times in California because regulators changed the permitting process midstream and regulators couldn't appreciate the impact of another six-month delay. If the project had died, the company would have died and likely the technology with it. We cannot allow promising technologies to die on the vine just because of regulatory friction.

CONCLUSION

The challenge we face as a nation is complex. The solutions need not be. We have to be careful not to let the perfect be the enemy of the good as we take steps toward reinvesting in our infrastructure and renewing our competitive position in the world. We must also recognize the extraordinary urgency of this challenge. The pressure is building on entrepreneurial American energy companies to move to China or Europe to be close to growing markets, to secure financing for that first

commercial facility, or to snag additional research & development funds. So the challenge is not just about supporting the most promising growth sector of the next several decades. It is about ensuring that America builds the next generation of energy technologies that will be the bedrock of our economic competitiveness over the coming century.

If we act now, we can do this. If we let national interests supersede parochial interests, we can do this. We can harness the ingenuity and drive that we see every day in our entrepreneurs, and leverage the strength of our private markets to maintain our leadership and secure our economic prosperity for decades to come.

That, I am confident in.

Thank you for your time here today. I look forward to your questions.

The CHAIRMAN. Thank you very much.

Mr. Auerbach, go right ahead.

STATEMENT OF NEIL Z. AUERBACH, MANAGING PARTNER, HUDSON CLEAN ENERGY PARTNERS, TEANECK, NJ

Mr. AUERBACH. Mr. Chairman, ranking member, members of the committee, I thank you for the opportunity to testify before this committee today. It's an honor to be here.

My name is Neil Auerbach. I'm the founder and managing partner of Hudson Clean Energy Partners which is a global private equity firm headquartered in the United States and focused exclusively on investing in the clean energy sector. A large percentage of our investor base is from the United States and a substantial number of our investments are in companies that are located here.

I have focused on many industries during my career in financial services. But for the past 9 years, the clean energy sector has been my passion. I'm here today speaking in my individual capacity to offer my perspective on investment and policy trends in this sector.

I believe that compelling national interest if served by increasing both the manufacturing and deployment of clean energy in the United States. It advances the interest of energy security, economic growth and environmental protection better than any other sector of the energy industry. However, I am not coming here before you in opposition to any sector of our energy industry.

The United States has a strong interest in maintaining a well diversified portfolio of energy assets. As an investor I understand well the value of diversification. In essence my recommendation to this committee is to maintain a diversified portfolio with an overweight to clean energy. My investment horizon in making that recommendation is the next 10 to 15 years.

What prompts me to make this recommendation?

My written testimony answers this question in detail. But I'm going to draw your attention to Figure 1 on page 4 of my testimony which is also blown up in front of you. I'm sorry I can't see some of the Senators to my left. But hopefully you'll focus your attention on this chart.

There's a lot of information to unpack on this chart. I'm going to simplify it for the committee. In essence in the power industry all power sources start out expensive and only get cheap as technologies improve and as economies of scale kick in.

In comparison to coal fired, natural gas fired and nuclear powered generation the wind and solar industries have proven themselves much more adept at reducing the cost as technologies improve and economies of scale kick in. As the leading investor in and a close observer of this sector for the past 9 years I look at the

trend lines. They favor clean energy. If you'll note on this here the steepest trend is for wind and solar. Solar in particular coming down that dotted line, coming down on the right, indicates the pace at which the cost of wind and solar are declining. That's what I'm focusing on.

In my written testimony I review a number of policy tools used by the United States and its trading partners to promote clean energy manufacturing and deployment within the borders. I'm not going to go through all of them with you now. Many of them have already been mentioned by my colleagues on this panel.

But I'm going to highlight 2 for you this morning.

One is reverse auctions for deployment of clean energy.

The other are financing incentives such as loan guarantees for promoting manufacturing of clean technology products.

As the production and investment tax credits begin to expire between 2012 and 2016 Congress needs to explore replacement options. I believe that reverse auctions are an attractive solution that I hope would receive strong bipartisan support. The question is why.

First of all, reverse auctions use the market rather than the government to arrive at the lowest cost incentive to meet deployment targets.

Second, because reverse auction system can be designed to enable the emergence of a national renewable energy credit market which is one of the goals of a national renewable portfolio standard.

Third, the system can be designed and implemented without adding to the Federal budget deficit.

To incentivize manufacturers to locate their facilities in the United States, financing incentives are critical. Based upon my direct personal experience overseeing Hudson's portfolio and I discuss 2 examples, very compelling examples in my written testimony. I strongly believe that Federal financing incentives such as the Loan Guarantee Program do create thousands of jobs in the United States that probably would have been created offshore without those incentives all the while preserving U.S. technology leadership in one of the world's fastest growing industries.

Thank you.

[The prepared testimony of Mr. Auerbach follows:]

PREPARED STATEMENT OF NEIL Z. AUERBACH, MANAGING PARTNER OF HUDSON CLEAN ENERGY PARTNERS, TEANECK, NJ

CURRENT GLOBAL INVESTMENT TRENDS IN CLEAN ENERGY TECHNOLOGIES AND THE IMPACT OF DOMESTIC POLICIES ON THAT I

Mr. Chairman, Ranking Member, members of the committee, thank you for the opportunity to testify here today. It is truly an honor.

My name is Neil Auerbach, and I am the Founder and Managing Partner of Hudson Clean Energy Partners. Hudson Clean Energy Partners is a global private equity firm that focuses exclusively on investing in the clean energy sector. With over $1 billion in assets under management, Hudson is a leading global investor in sectors that include wind, solar and hydroelectric energy, biofuels, biomass, smart grid, electric vehicles, energy efficiency and storage. Given our position on the front lines of these fast-growth industries, we have seen firsthand the impact of government policies on our sector, both at home and abroad. I would like to offer some observations about how government policy impacts private sector capital flows, and then offer some suggestions as to how the United States can become a more attractive place to invest, create jobs and generate wealth through adoption of smarter poli-

cies. Before I begin, however, I would like to summarize the reasons why encouraging the growth of the clean energy sector is of paramount importance to the United States.

Why the United States has a compelling interest in clean energy[1]

Increased manufacturing and deployment of clean energy in the United States serves three compelling national interests: (1) energy security; (2) environmental protection; and (3) economic growth. No other part of the energy industry can lay claim to impacting so many fundamental interests of the United States. To date, the policy response of the United States has not adequately supported a sector critical to so many fundamental national interests. Much impassioned rhetoric has been intoned in debates about the merits of supporting one part of the energy industry or the other. I am not here today as an opponent of any part of the energy industry, including the coal, oil, natural gas and nuclear industries. I am a realist. Dreams are not part of my investment thesis, and I harbor no illusion that any clean technology breakthrough can, will or should eliminate any of these industries. Furthermore, as an investor, I understand the value of portfolio diversification. If we have learned anything about energy over the past decade, it is the importance of maintaining an adequate, diversified supply of energy. As an advocate of, and leading investor in, the clean energy field, I heartily recommend an "overweight" to the clean energy sector. My view is that a more fulsome understanding of why increased investment in clean energy is of such vital national importance can better inform the important dialogue about the most appropriate means to do so.

The benefit of clean energy to U.S. energy security should be obvious, but it warrants discussion anyway. In our transportation sector, dependence on foreign oil weakens our national security. I have nothing new to add to clarify what is already abundantly evident. However, what might not be so clear to this Committee is the progress being made in the search for long term replacements for oil as the primary energy source for our transportation sector. Currently, the two most viable, long term replacements for oil are biofuels and hybrid/electric vehicles.

While second generation biofuel technologies have not matured to a point where the cost curve could be definitively predicted, major corporations in the energy space, including Chevron and ExxonMobil, have made significant investments in these technologies. As an example, ExxonMobil plans to invest as much as $600 million in algae-based biofuel production, with a significant percentage going to Synthetic Genomics, a California-based firm whose CEO is Craig Venter, one of the human genome decoders. Some expect genomic science to be the key to yielding a significant decrease in the cost of the biofuel production cost curve. A more mature field is the Electric Vehicles ("EV") market, where we have seen volumetric energy density of lithium-ion batteries, the most expensive component of a hybrid/electric vehicle, improve by a factor of 2 and cost decline by more than 70% during the last ten years. As production of these components scales, the cost is expected to decline by another 70% by 2015.

If you accept the premise that there is a progress curve at work reducing the cost of advanced batteries powering the next generation of our transportation fleet, then smartly crafted incentives that accelerate deployment of hybrid/electric vehicles serve a national goal of improving energy security by reducing the dependence of the United States on foreign oil. Admittedly, the truth is a bit more complex than that, as we need to understand better the vulnerabilities of the U.S. power grid as it accommodates its new electric vehicle fleet, as well as the vulnerability of the supply chain of electric vehicles, particularly as it pertains to the lack of globally distributed supply of rare earth minerals.

Increased investment in clean energy clearly improves U.S. energy security in the power sector as well. The tragedy unfolding in Japan has put a spotlight on the security risks associated with nuclear power, as well as the environmental risks.[2] A nuclear power plant seriously damaged by a natural disaster may take years to rebuild, even if the damage causes no harmful radiation to escape into the atmosphere. The aftermath of Hurricane Katrina illustrates the vulnerability of many of

[1] The term "clean energy" has many definitions, as many industries want the moniker of being called "clean." Here, I used the term to refer to renewable energy (wind, solar, biomass, geothermal, hydropower, biofuels) and energy smart technologies (including smart grid, building efficiency, industrial efficiency, transport efficiency and storage).

[2] I am not an expert in the nuclear power field, and offer no opinion on an appropriate policy response to the concerns being raised about the safety of our nuclear fleet in the wake of Japan's national disaster

our nation's natural gas wells and pipeline infrastructure.[3] Renewable energy sources, particularly wind and hydro, have a long history of safe and reliable operation and are far less vulnerable to massive disruption. For example, most wind turbines are designed to stop spinning in a hurricane, and are designed to withstand winds in excess of 150 mph.

Improving our environment has been a national goal and has been enshrined in numerous pieces of legislation, most notably, the Clean Air Act of 1970, amended in 1990, and the Clean Water Act of 1972. In this regard, the nation continually searches for more environmentally friendly methods to utilize its resources for energy production. Not only does clean energy reduce the harmful environmental impact associated with elevated levels of greenhouse gases, it also offers the best way to reduce other harmful pollutants in our atmosphere such as carbon monoxide, sulfur dioxide, oxides of nitrogen, particulates, volatile organic compounds and hazardous air pollutants (e.g. mercury).

Finally, investment in clean energy promotes economic growth. The clean energy market is forecast to triple in size during this decade, from $740 billion to over $2 trillion, exceeding global GDP growth even under the most conservative growth scenario.[4] The U.S. currently accounts for 21% of the clean energy market, but its pole position is under competitive threat. China, which now accounts for 17%, is expected to rise to account for 24% of the global clean energy market by 2020. As is written in an old Chinese proverb, it is impossible to stay in one's current position in a rapidly moving river. Either one paddles hard to move ahead or one will be washed back.

Many critics of clean energy express concern about the elevated cost of clean energy technologies as compared to their fossil fuel counterparts, and posit that any support of alleged uneconomic industries cannot possibly foster economic growth over any prolonged period of time. Others focus on the small installed base of clean energy technologies and wonder whether any of them can ever reach the scale necessary to make a meaningful contribution to our long term energy supply.

Both concerns are utterly misplaced, and the underlying myths must be exposed. All conventional energy sources used for our electricity grid have begun as very expensive power sources and have only gotten cheaper as economies of scale have kicked in. Figure 1, which comes from an article published by my colleagues in the Journal of Environmental Finance,[5] catalogues the history of price movements of electricity powered by coal, natural gas, and nuclear energy since 1930. History teaches us that each of these power sources has required achieving massive scale in order to achieve their current favorable cost structures.

Hudson's research uncovered that the slow improvement in cost structure accompanying massive increases in scale is not taking place in the wind and solar industries. Rather, small increases in scale are causing significant improvements in their cost structures. Figure 1* clearly demonstrates that wind and solar energy have reduced cost more rapidly than any other type of conventional energy source over the last 80 years.

The rapid reduction in clean energy's cost structure is projected to continue, and will bring these technologies into grid or retail parity with conventional power sources over time, even cheaper than conventional power sources in more and more markets over time.

An annual survey of cost competitiveness of various forms of electricity generation conducted by Lazard confirms this view. Figures 2 and 3 compare the wholesale and retail power prices for several clean and conventional power sources, and shows their expected cost migration from 2010 to 2015. Most striking is the forecast of rapid cost declines for solar power. Data sources point to solar panel price declines of approximately 50% over the past two years.[6] Lazard's cost forecasts for the wind industry are probably conservative, and do not adequately account for intense price competition underway in the wind turbine market that have resulted in cost declines exceeding 20% over the past 3 years. Significant further price declines are expected as leading Chinese wind turbine manufacturers with lower cost structures, as well as newer wind turbine models sporting improved wind turbine efficiency, enter global markets.[7]

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[3] The natural gas supply disruption resulting from Hurricane Katrina cost the consumer approximately $8.5 billion in higher natural gas prices during the 45 day price spike that followed the hurricane, exclusive of the cost of replacing damaged infrastructure.

[4] HSBC Global Research, "Sizing the climate economy", September 2010.

[5] Environmental Finance, "Making the Case for Clean Energy", December 2010—January 2011.

[*] All figures have been retained in committee files.

[6] Hudson estimates

[7] Emerging Energy Research and market quotes from OEMs

The concern I mentioned earlier about the scalability of clean energy technologies is easily dismissed and I won't spend much time debunking the myth. The wind industry today installs approximately 38 GW of wind turbines globally every year. The solar industry has grown exponentially over the past 7 years since I entered the industry. Only 1 GW of solar panels was installed in 2004. Last year, nearly 17 GW of solar panels were installed globally, and the industry is forecasting annual installations of solar panels inexcess of 40 GW by 2014. By comparison, approximately 50 GW of nuclear power were installed from 1990 to 2007.

No one needs to be concerned about the world's access to commercially utilizeable wind and solar resources. Figure 4 should allay any concern that we're running short on either resource any time soon.

If the importance of clean energy to vital national interests is so clear, and the improvements in the cost structure of various clean energy technologies is so rapid, why am I here advocating for increased federal support for clean energy? There are essentially three reasons: (1) innovation is not integral to the energy industry; (2) the degree of federal support for clean energy is not commensurate with its strategic importance, as discussed above; and (3) I sense that the federal government may not be fully aware of the competitive environment in which other countries are demonstrating greater commitment as well as skill in supporting the growth of clean energy manufacturing and deployment within their borders.

Energy is a commodity, not a consumer product

Energy is a commodity that affords consumers little opportunity to express a preference in where it originates or how it is produced. The market lacks a demand function that allows producers to supply different products with different cost structures, as for example, in the case of consumer electronics, where consumer preferences drive manufacturers to invest in innovation and product diversification. In electricity markets, there is baseload power, peak power, and off-peak power at the wholesale level. At the retail level, there is the light switch, and in certain markets, the ability to express some preference in how to buy electricity through smart meters.[8] In the absence of a market incentive to encourage investment in new energy sources other than that needed to meet new demand or obsolete supply, newer technologies have a hard time getting to scale.

As pointed out by The American Energy Innovation Council in its inaugural 2010 report[9]:

> There are two reasons the government must play a key role in accelerating energy innovation.
>
> First, innovation in energy technology can generate significant, quantifiable public benefits that are not reflected in the market price of energy. These benefits include cleaner air and improved public health, enhanced national security and international diplomacy, reduced risk of dangerous climate change, and protection from energy price shocks and related economic disruptions. Currently, these benefits are neither recognized nor rewarded by the free market.
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> Second, the energy business requires investments of capital at a scale that is beyond the risk threshold of most private-sector investors. This high level of risk, when combined with existing market structures, limits the rate of energy equipment turnover. A slow turnover rate exacerbates the historic dearth of investments in new ideas, creating a viscous cycle of status quo behavior.[10]

Global investment in clean energy is surging

When I entered the clean energy sector in 2004, global investment in our sector was approximately $50 billion. In the last seven years, global investment in clean energy surged fivefold to nearly $250 billion, over 30% ahead of 2009. In 2004, the United States was the destination for approximately 20% of the clean energy capital invested in the sector, while China accounted for just 3%. Last year, however, the United States dropped to 19% of global clean energy investment, and China recorded over 20% of that investment.

Our international trading partners, conspicuously led by China, are laying plans for massive investments in the clean energy sector. They are witnessing the dra-

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[8] For example, smart meter rollouts in selected regions across the country offer customers Time of Use pricing.

[9] American Energy Innovation Council, "A Business Plan for America's Energy Future", 2010.

[10] The report points out that research & development spending as a % of sales is 18.7% of the pharmaceuticals industry, 11.5% of aerospace and defense, 7.9% of computers and electronics, 2.4% in automotive and 0.3% of the energy industry.

matic growth of vibrant markets for clean power and energy smart technologies, such as smart grid, ultra high capacity transmission, advanced energy storage, LED lighting, and electric vehicles, as they seek to address the energy infrastructure needs of their own economies while nurturing the growth of export-driven industries. Other countries have succeeded in attracting significant amounts of capital for investment in manufacturing and deployment, and have used a wide variety of policy tools to attract that capital. Although the types of policy tools employed by countries to accomplish their clean energy goals vary widely, most of the policy tools fall into the following four categories: (i) installation mandates or targets; (ii) revenue incentives; (iii) manufacturing incentives; and (iv) financing incentives.

Installation Mandates and Targets

Three of the most active countries last year in attracting capital for deployment of clean energy had either a mandate imposed on utilities or grid operators, or targets that had the respect of both the private and the public sector. China leads the world in both the pace of new policy adoption as well as the scale and scope of its ambition. New clean energy targets include (i) 15% renewables in primary energy consumption by 2020, and (ii) 35%—40% energy intensity reduction by 2015 from 2005 levels. In gigawatt terms, China seeks to deploy roughly 7.6 times the amount of clean energy in 2020 as compared to its 2009 levels.

While federal policy toward clean energy has not kept pace with other countries, the United States has benefitted from a wide range of state and local policy incentives directed at financing the scale-up of clean energy. Texas, California and New Jersey represent the top three U.S. states in terms of installed renewable energy capacity, with their combined installed capacity exceeding one-third of the U.S. total. California leads the country with a 33% Renewable Electricity Standard ("RES") by 2020, an active Renewable Energy Credit ("REC") market, the California Solar Initiative and state feed-in tariffs. Texas has implemented a mandate to produce 5.9 GW of renewable energy by 2015 and 10 GW by 2025. New Jersey has set a target of reducing greenhouse gas emissions 80% from 2006 levels by 2050.

Leading the way in Europe, Germany has set an accountable target to achieve 80% of electricity from renewable sources by 2050 while also adhering to the EU's 20% by 2020 target.

Revenue Incentives

Revenue incentives have been one of the most popular and impactful policy tools to stimulate investment in clean energy deployment. Some of the more popular tools have been feed-in tariffs[11], renewable energy credits[12], tax credits, and carbon credits. Several of these policy tools have been criticized, most notably feed-in tariffs, as overly generous in cases where Government agencies have attempted to set market prices based on often-outdated information about the rapidly evolving industry cost structure. For example, in Spain, a generous feed-in tariff of approximately #455/MW hour for solar power resulted in a building boom of over 3,200 MW of solar capacity over a two-year period between 2007 and 2008, representing over 35% of the global solar market at the time. Gross margins for various suppliers of solar panel components exceeded 80% for some companies taking advantage of the Spanish Government's largesse, until Spain fitfully redrafted its feed-in tariff rules in late September of 2008, causing massive dislocations in the global supply chain.

A much more market friendly and disciplined form of revenue support has gained considerable traction. Reverse auctions, used successfully in many other industries, have recently been used with great success in Brazil, in place of its former feed-in tariff system, to auction off nearly 2.1 GW of wind energy tenders, and resulted in a 42% average price drop in the price paid for wind energy in comparison to the feed-in tariff previously in force.[13] In concept, reverse auctions are simple. They are auctions conducted by buyers to encourage sellers to sell at the lowest possible price. In practice, reverse auctions require careful planning to ensure a successful outcome.

As this Committee considers how to support the accelerated deployment of clean energy in the United States at the lowest possible cost to the Government and consumers, reverse auctions are a compelling option. I will discuss the benefits of this approach for the U.S. later in my testimony.

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[11] For example, Spain, Germany, China, UK and Ontario Province, Canada.

[12] Includes RECs in various states, green certificates (Italy), renewable obligation certificates (UK).

[13] 13 Bloomberg New Energy Finance, "Wind Tender Analysis in Brazil: Winner's Curse?", September 2010.

Manufacturing Incentives

Incentive programs in foreign countries for the deployment of clean energy have made relocating U.S. manufacturing facilities overseas extremely attractive. In China, Malaysia, Brazil and others, mechanisms such as free-trade zones, long-term tax holidays, cheap electricity, accelerated permitting and cash grants have led to increased clean energy deployment as well as meaningful job creation.

To achieve installation targets, some governments explicitly require a certain amount of domestic content to drive manufacturing. China and the Province of Ontario have employed competitive domestic content rules to maximize job creation from domestic subsidy programs, which has attracted substantial domestic and foreign capital to these areas. China has implemented a 70% local content requirement, which has forced some of the largest players to build manufacturing hubs in these areas.

In the United States, we have been fortunate to have the manufacturer's tax credit (MTC) under section 48 (C) of the Internal Revenue Code. One of Hudson's portfolio companies, Calisolar, has been awarded a $51 million MTC for its solar cell manufacturing facility in Sunnyvale, California. That manufacturing facility has been built, in part, with the proceeds of that MTC award. It is important to note, however, that Calisolar faced a challenge in utilizing all of the MTC that many other recipients of the MTC probably faced. The MTC program assumes that the award recipient pays current federal corporate income tax, since the award entitles the recipient to reduce its federal income tax liability. Many young, innovative companies simply haven't matured sufficiently to generate the level of profitability needed to incur a tax liability against which to apply the MTC. Instead, these companies must hire brokers, accountants and lawyers to identify other companies that pay tax and would be willing to "pay" to "buy" the credit, so that the award recipient receives the intended economic benefit. One suggestion for improvement of the MTC program is to allow award recipients to apply to the Treasury Department to receive the award in cash, much like the current 1603 program for the investment tax credit. Administrative guidelines have been established that permit taxpayers to rely on the transparency of the procedures that must be followed to claim the credit, while providing the Government with an efficient oversight mechanism so that the cash paid in lieu of the credit goes to the intended recipient.

Financing Incentives

A key enabler of both clean energy deployment and manufacturing has been the provision of financing and financing assistance from public funding sources. The clean energy industry is very capital intensive. Renewable technologies, in particular, effectively convert operating expenses normally incurred over 30 or more years (e.g., fuel costs) into up-front capital expenditures for the installation of the generation equipment. For example, a combined cycle gas plant can be built for approximately $1,000 per kilowatt of capacity, whereas a wind farm requires approximately $1,900 per kilowatt to install, and a solar plant requires approximately $3,000 per kilowatt to install.[14] Access to reasonably priced capital is critical to ensure that clean energy manufacturing and deployment can take place at low cost and on time.

In this regard, the United States has struggled to keep pace with many of its international trading partners. For example, in 2010, the Federal Financing Bank supplied over $2 billion in financing to the clean energy sector, whereas China Development Bank supplied over $35 billion in financing to its clean energy sector.[15] In Germany, KfW, a state-owned bank, loaned #9.6 billion to the clean energy sector. In the United States, nearly $46 billion was invested in the clean energy sector in 2010, of which approximately 10% received federal financial assistance, primarily in the form of loan guarantees.

International support is growing for the provision of financing incentives, and there is no evidence that China Development Bank intends to slow down its pace of capital commitment to the sector. For example, the UK is seriously examining the support for a "green bank" that will act as a lender to and guarantor of private market participants in their domestic clean energy industry.[16]

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[14] In the case of wind and solar energy, once the plant is built, the fuel is free.

[15] Bloomberg New Energy Finance, "China Development Bank—How It Came to Be a Giant Lender to Clean Energy", 11 March, 2011

[16] Green Investment Bank Commission, "Unlocking Investment to Deliver Britain's Low Carbon Future".

The case for continuing federal support for clean energy manufacturing and deployment in the U.S. is clear

I acknowledge that the United States desperately needs to put its financial house in order, and that the size of the federal budget deficit will constrain its ability to spend money in the pursuit of its interests. I also acknowledge that the realm of government accounting is not an expertise that I possess, and so the ultimate choices made by this Committee in advancing legislation is likely to be shaped by budgetary rules and limits that I simply cannot anticipate. With those caveats, I believe that the United States cannot afford to cede technology leadership in one of the world's fastest growing sectors that addresses so many core national interests any more than it can afford to spend the taxpayers' money far faster than it collects it. But in this climate of budgetary constraints, I also believe that there are approaches that can be taken to promote clean energy that do not impose a material burden on the federal government.

It seems implausible to me that the United States can again enjoy sustained periods of brisk economic growth without producing high value goods and services domestically that are in demand both here and abroad. The ability of the United States to compete effectively in key industries is in peril in the absence of bolder leadership by the federal government. Below, I discuss the importance of existing federal programs and the need to think more broadly about the direction of future policy.

Historical Perspective: the Development of Solar PV Manufacturing

Though Asian manufacturers dominate the solar industry today, the solar industry was born in the United States, and U.S. firms led the world for decades. Sadly, and quite avoidably, the center of gravity moved abroad at precisely the time the solar market began to take off. Why? Largely because other countries created attractive policy incentives to promote local demand and local manufacturing.

Scientists at Bell Laboratories developed the first crystalline silicon photovoltaic cell in 1954. Four years later, the U.S. Vanguard space satellite carried a small array of PV cells to power its radio.

The U.S. market for solar energy systems grew in the early 1980s in response to federal and state programs and incentives such as income tax credits, property tax exemptions, sales tax exemptions, costsharing grants, government purchasing programs, and government-funded demonstrations. In 2004, before the solar industry began its most recent dizzying growth spurt, the United States was the home to approximately 10% of the world's solar manufacturing capacity. Today, only around 6% of worldwide PV cell production takes place in the United States and approximately 59% of global cell production takes place in China[17].

In late 2005, I spearheaded the pre-IPO investment made by Goldman Sachs into First Solar, which today is the world's most successful solar company. Although First Solar is based in the United States, most of its solar panels are manufactured outside of the U.S. Time will tell if my prior investment success will be repeated with the two solar companies currently in Hudson's portfolio. That being said, I am convinced that both companies have the technology promise and the cost discipline to emerge as leading contenders in the next wave of great solar companies that is emerging in this fast-growing industry. What is important to note for this Committee is that both companies have expressed a strong interest in locating their next manufacturing facilities in the United States, and that the Loan Guarantee Program is of critical importance to each company's decision.

Calisolar is a California-based manufacturer of silicon, wafers and cells that are sold to manufacturers for use in making solar panels. Calisolar is unique in its ability to manufacture silicon feedstock that is much cheaper than conventional silicon without compromising quality. With manufacturing scale only a fraction of its more established competitors, Calisolar is manufacturing its silicon far cheaper than most of its industry peers. And in an all-too-rare industry role reversal, our American company is exporting its product to China. When Calisolar builds its first large-scale manufacturing facility, we believe it will be the lowest cost manufacturer of silicon in the world.

Facing the choice of whether to locate this large-scale manufacturing facility in the U.S. or elsewhere, Calisolar sought out the best incentives available. The most compelling incentives to build a plant in the U.S. have come from individual states seeking to attract new jobs. State incentives have included: preferred power prices, low-cost land and buildings, free trade zones, grants for job training, and assistance with permitting and necessary approvals. Asian countries are currently offering

[17] Solarbuzz 2011

similar incentive packages and access in the U.S. through the Loan Guarantee Program to the type of low cost financing offered by many Asian nations would help a company in Calisolar's position to choose to locate its next manufacturing facility inside of the U.S.

Another example of how the Loan Guarantee Program is helping companies in our portfolio select the United States as the home of their next manufacturing facility is SoloPower. SoloPower is a Californiabased manufacturer of unique lightweight, flexible, high-power solar panels that possess critical advantages for both rooftop and ground mount solar market applications. By flexible, I mean thin, bendable, and utterly unlike the traditional flat-plate solar panels familiar to most people attending today's hearing. This unique form factor expands the total addressable market for solar energy given that approximately three quarters of commercial and industrial rooftops in sunny environments are not designed to bear the load of rigid glass solar panels, which weigh about five times as much as SoloPower's panels. SoloPower's product can be integrated into a roofing membrane and unrolled on a rooftop much like carpeting. Alternatively, it can be adhered directly to a rooftop without the need for physical penetrations or racking systems. This speeds installation time and reduces balance-of-system ("BOS") cost, delivering an industry-leading levelized cost of energy that is competitive with retail electricity prices in many regions of the world.

Demand for SoloPower's product far exceeds its current manufacturing capacity, and the company has decided to build a large-scale manufacturing plant in the state of Oregon. The company selected Oregon because of the attractive incentives made available at the state and local level, including: low-interest loans, cash grants, and a state tax credit that can be converted into upfront cash through partnership with a local taxpayer. In addition, SoloPower received a conditional commitment from the U.S. Department of Energy for a $197 million loan guarantee. Without these incentives, SoloPower probably would have located its manufacturing operations outside of the United States.

Historical Perspective: Development of Hybrid-Electric Vehicles

The history of hybrid/electric vehicles tells a similar story. Thanks to the Toyota's Prius, most people assume that the hybrid electric vehicle was invented in Japan. In truth, the first full-sized hybrid vehicle was built in America in 1972. This first hybrid was not a Toyota, but rather a Buick Skylark which had been provided by General Motors and converted by an American engineer named Victor Wouk. The underlying technology behind the nickel-metal hydride ("NiMH") battery, one of the most important components of today's hybrids, was invented by Stanford Ovshinsky, an American and founder of the Ovonics Battery Company. General Motors acquired the NiMH battery patents from Ovonics and shut down GM's Electric Vehicles program before the battery could be commercialized. The patents ultimately ended up under the ownership of Chevron, which took no steps to deploy the technology in the U.S.

U.S. automakers would have been less likely to miss out on the opportunity of leading the world in hybrid vehicle technology if not for a stagnant government policy which failed to focus on an energy efficient future. In 1978, the Corporate Average Fuel Economy ("CAFE") standard for passenger vehicles was 18.0 miles per gallon. By 1990, it had increased to 27.5 miles per gallon. And for the next 20 years, until 2011, the CAFE standard remained at 27.5 miles per gallon. In the meantime, Japanese automakers were busy seizing the lead in hybrid vehicles using NiMH batteries as it sought to build vehicles for consumers seeking more fuel efficient vehicles. In 1997, Toyota unveiled the Prius, capitalizing on consumer interest in fuel efficiency. The rest is history.

With respect to the new generation of EVs, the batteries of choice are based on lithium ion technology. It should be no surprise that the underlying technology came from the U.S.: experimentation with lithium batteries begun in 1912 under G.N. Lewis, the dean of the chemistry department at University of California at Berkeley, and a research team led by an American chemist John B. Goodenough in the 1980s advanced the technology substantially and made commercialization possible. Today, Japanese manufacturers are the leaders in lithium-ion battery production, with South Korean and Chinese companies making significant inroads. U.S. battery companies, including A123 and Ener1, have excellent designs, but have outsourced their initial production overseas. However, with federal support now in place, Ener1 is building a plant in Indianapolis and A123 plans to build in Michigan. The lithium-ion battery market is projected to become a $40 billion market globally by 2020, so it is imperative that support continues for battery manufacturers.

California, the leading test ground for electric vehicles, passed its Zero Emission Vehicle ("ZEV") Mandate, which required two percent of the state's vehicles to have

no emissions by 1998 and 10 percent by 2003. However, the law was repeatedly scaled back over the following decade to reduce the number of pure ZEVs it required.

Developing a New Approach that Provides Effective Support for the Clean Energy Industry

Over the last several years, Congress has explored enactment of a number of approaches for promoting clean energy. Such approaches have great merit for this industry. But in this era of severe budget constraints, I recognize the importance of finding an approach to clean energy support that imposes limited costs on the federal government.

Speaking from the industry's perspective, clean energy developers seek certainty and long-term support for their investments. As I have explained above, the reverse auction approach has had great success in other countries because it provides certainty to the industry. And it has great appeal to consumers because it drives down the cost of renewable power. I have been working with industry partners on a reverse auction approach that would (1) use a market-based approach to incentivize renewable development at the least cost; (2) would promote the development of a national REC market; (3) would transition the industry away from reliance on federal support; and (4) would not add to the federal budget deficit. I would be honored to appear before this Committee again at a later date to discuss reverse auctions and their potential role in U.S. energy policy in greater detail.

This Committee, and others in the Senate and House, will examine many specific pieces of legislation during this session of Congress. I have mentioned reverse auctions and financing incentives in my testimony today. Let me briefly discuss how they fit together. Depending upon the structure of a federally supported reverse auction program, further financing incentives offered by the United States might not be required to accomplish national clean energy policy goals for commercialized technologies. The devil is in the details. However, consideration of a federal reverse auction program must be coupled with assurance to the market that existing federal support mechanisms for clean energy will remain in place and will sunset as currently envisioned. With those ground rules in place, market participants will be encouraged and no unintended consequences will take place.

For technologies that are reaching the commercialization phase, risk capital will flow best from the private sector if federal support is focused on minimizing the cost of capital and improving access to liquidity through successful financing incentives such as the Loan Guarantee Program.

Conclusion

The U.S. has been the global leader in inventing the clean energy products that the world is currently using, and that leadership position, while threatened, has not yet been lost. However, without a national commitment to becoming a global manufacturing leader, and consuming those products at home to reinforce scaling of the market, the United States will not be able to retain its technology edge. With a bold renewed determination to reassert its leadership role in manufacturing and deploying critical technologies in the clean energy sector, the United States can retain its technology edge, create an abundance of high-value-added jobs, and afford Americans the opportunity to build a more prosperous economy.

I thank the Committee again for the opportunity and honor to present my views on this important topic of national interest.

The CHAIRMAN. Thank you very much. Thanks to all of you for your testimony.

Let me just start, Mr. Auerbach, to ask you if you would elaborate on how the reverse auction proposal that you're advocating would work and how—what action Congress would have to take to put such a thing in place?

Mr. AUERBACH. Sure. There is actually a bill in front of the House right now. It's of interest.

I'm not a political observer. I'm an investor. But it's interesting that there are a large number of Republicans that are signing onto the bill as part of a larger package but it does support clean energy.

So I think that one piece of good news is that there are a lot of Republicans that believe, at least in the House, that a reverse auc-

tion market can work. In essence what you need to do is to focus on a revenue source that is currently outside of the scoring. So it would be a new source of revenues and to put those revenues into a trust fund.

Then to designate a reverse auction authority that would in effect put out to bid those that have clean energy assets say on a quarterly basis or semi-annually basis in different parts of the country. They would enter bids to take cash out of that trust fund in order to supplement their revenue streams to ensure that those investors in clean energy earn the adequate rate of return. It's outlined in that piece of legislation, that draft.

We believe or I believe personally that are some important improvements that could be made to not only allow for cash to come out of that trust fund, to supplement the revenue streams for sale of power in the markets. But can actually be designed to encourage the formation of a national renewable energy credit market. The way that one would do that is in effect by having only clean energy assets in States that have state renewable portfolio standards be eligible to participate. Once you do that the States will come piling on board. They will want to participate.

There's a lot more here. I'd be delighted to elaborate on this and answer questions. But if the Chairman would permit I've done a lot of thinking about this. I'm working with other industry partners. I would love to submit a supplementary paper for the record that would outline some of these ideas.

The CHAIRMAN. We'd be anxious to see that. Why don't you go ahead and do that.

Mr. AUERBACH. Thank you.

The CHAIRMAN. I think it's an interesting concept. One we need to understand better.

Mr. Coleman, let me ask you.

I think you point out and I think it's clear that China has overtaken the United States as far as in the production of photovoltaic cells and wind turbines. I gather that—I guess my question is are we to a point, say in the case of photovoltaic cells, where you're almost to a commodity situation where the competition is so fierce or is headed in that direction that the margins of profit are going to be so limited that it's not going to be realistic for U.S. firms or others to really get in and compete in that area. I don't know what your thought on this is?

Mr. COLEMAN. I think we've hit a point now where there's obviously quite a bit of volume in the market. I think the Chinese are clearly doing quite well in that. I think their approach to crystalline, silicone, in particular has changed the dynamics in the market.

On the other hand, you know, we're investors in several companies that we think can get to much lower costs than what exists out there in the market today. We do believe that there will be room for those players in the market. But I think we, as the American economy do lead in several commodity industries where we do compete and we have large businesses here in the U.S. around those commodity industries.

So I don't think the fact that it's a commodity is a problem. I think part of the challenge of investing in the sector is that you are

investing in commodity industries in a lot of sectors. But what you need to do is you need to find technologies that have the potential to get below the competition on the cost curve. That's going to mostly happen at scale.

The CHAIRMAN. Let me just ask one other question.

Senator Stabenow and I and many others here have strongly advocated for putting additional money into this tax credit, 48C. I'd be interested in your thoughts as to whether that worked as it was intended to, whether that should be continued. I know the President is a strong advocate on it.

Do you have any thoughts? Then Ms. Gallagher might have a thought on it.

Mr. COLEMAN. Yes, so, I think the 48C program is a great program in its design. I think that it came at an important time for a lot of these technologies. I think the fact that it's targeted at manufacturing and prioritizes some of the innovative technologies out there. If you see it to what technologies it went to it's actually been very good.

I think the challenge with 48C has really been in the execution and deployment of it which is that as startups and this is really a challenge for startups engaging with some of the larger tax credit programs and what not that the government provides. As startups they don't necessarily often meet the criteria that the OMB or other, the Treasury puts out there. So the challenge of 48C is that—has been that a lot of the companies that have won 48Cs have had trouble monetizing it. Part of that is that they've had to go to third parties to try and figure out ways to—people who actually had the tax appetite.

Then the other challenge is that there's some requirements around the balance sheets of these businesses. These businesses are typically, especially the early stage ones, you know, they're funded in 18 to 36 month cycles. So they're not—they don't have 5 year horizons on their balance sheets and cash-flows in a way that is often required to access some of these tax credits.

So I think it's a great program. I think working out some of the kinks in the execution is important. We'll be happy to work with any offices in trying to do that.

The CHAIRMAN. Ms. Gallagher, did you want to make a comment on that or not?

Alright.

Senator Murkowski.

Senator MURKOWSKI. Mr. Zindler wanted to——

The CHAIRMAN. Oh, Mr. Zindler, go ahead.

Mr. ZINDLER. If you don't mind I would add just a couple quick comments on both questions.

First on photovoltaics and I guess our view is that the answer is the current generation of photovoltaic technology has indeed become quite commoditized. Actually if you look at chart 6 that I've submitted. You can see that in the California market in the fourth quarter of 2010, Chinese modules accounted for about the majority of new capacity that was requested to be added under that State's solar initiative program. So we have seen a real commoditization.

That said. There is all still essentially to play for because if you look at the cost of generation from current PV technologies they are

still not competitive on a truly unsubsidized basis with the fossil generation. So the long term goal is indeed to drive down that learning curve that Neil showed earlier. Those—and thus at some point whoever is able to produce photovoltaics at a much lower cost is going to be, I guess you would say the winner in this long term game.

So we're not there yet. The market is being driven by subsidies today primarily California, Germany, other places like that.

Second, on 48C, if I could for just a moment. I would completely agree with Mr. Coleman's comments. Of the, I think it was $2.3 billion that was allocated we've tried to do some research into this.

It is not clear to me that all the companies on the list have been able to take advantage of the tax credits that were offered. In fact quite a few, I think, have not been able to. The larger, publicly traded ones that are profitable or attached to larger conglomerates with profits have been able to, but a number of the startups haven't.

I know that one of the ideas that has been kicked around is to be able to make the tax credit a cash grant or something else. I might suggest that that might work better potentially than the existing system.

The CHAIRMAN. Senator Murkowski.

Senator MURKOWSKI. Thank you, Mr. Chairman.

I mentioned in my opening comments that sometimes when we're talking about the U.S./China energy race, if you will, it's not entirely a fair comparison, that it may be a little bit apples to oranges. I mentioned a couple different scenarios there where people were displaced, environmental issues were at play. So it's not always about just getting the lowest cost. I think we need to keep that in mind.

I think we have accepted some tradeoffs here. We want to have fair labor standards. We insist on those. We want to have environmental compliance. We insist on that.

But Mr. Coleman, you mentioned another area that I think we suffer from some hurdles here in this country because of, call them bureaucratic delays or the red tape or just the government processes. You indicate in your example a 5 to 10 year process for testing. How much of the delay that causes us to be less competitive, I mean, we're talking about turning things around quickly, working to reduce that timeline that Mr. Auerbach has shown us.

How much does this play into our ability to be a competitor here out on the world scene? We're causing it ourselves. Mr. Coleman, if you want to start?

Mr. COLEMAN. Yes, so, I think it's a big challenge. I think that for whether it's renewables you're talking about or whether it's conventional energy sources. I think everybody is going through the challenge of deploying these technologies and the hurdles you have to jump through in order to do that.

You know, I think though that if you look at some of the—what I was referring to in terms of the 5 to 10 year process, that's really a challenge because you've got a regulated market where people don't have the incentive to take a risk. The challenge there is how we prioritize certain technologies or certain sectors that we think are strategic and therefore that we can push these technologies

through the pipe faster than they would otherwise. I think we are facing a bit of a challenge here in terms of cutting budgets on the one hand and then also having to deal with the friction, the market friction, on the other hand associated with regulation.

I think it's hard when you pick up the phone and you call an agency and there's no one there on Friday to answer the phone. I think we have to figure out how to handle that balance. Part of that is going to be streamlining regulations to accelerate some of the deployment of the technologies that we think are critically important to this country.

Senator MURKOWSKI. I've got a very important question that I want to ask that doesn't relate to this. But does anybody else want to comment?

Mr. AUERBACH. Yes, if I could—thank you, Senator Murkowski.

If I could just point to footnote 10 on page 7 of my written testimony. I highlight a report that perhaps many of the Senators have already read from the American Energy Innovation Council. It compares the percentage of research and development spending as a percentage of sales in a variety of industries. In the pharmaceuticals industry it's 18.7 percent, in the aerospace industry, 11 and a half percent, in the energy industry, 0.3 percent.

I think that that's a symptom of some root causes that Mr. Coleman mentioned and that the Senator asked questions about. So it's endemic to the industry. I think that it needs to be resolved if we are actually going to capture the mantle of leadership or retain that mantle of leadership in the energy industry.

Senator MURKOWSKI. Let me ask a question about the materials supply chain because I think this is an area where China is going, you know, literally from cradle to grave type of an approach. They've got all the cards when it comes to the front end of the clean energy supply chain. They've very aggressively expanded their minerals production and their processing capabilities for the raw materials that we need to manufacture clean energy technologies.

We're doing a lot of talking around here now about rare Earth minerals. We all know China holds 95 or 97 percent of what is being produced right now. They're using that as basically an energy weapon, if you will.

I think it's an extremely important issue. I think it plays into what we're talking about here in terms of the—how we lower the costs. We might be able to lower the financing of our clean technology projects.

But what difference does it really make if we're not able to gain some control over the front end. You've got a Nation like China that basically has made sure that every step along the way they've got the ability to be engaged. How big of an issue is this in your view?

Mr. Auerbach.

Mr. AUERBACH. Senator Murkowski, it is a big issue that China does have roughly 97 percent of the world's production of rare Earth minerals. But they only have approximately one-third of the actual resources, the 17 minerals in the Periodic Table that are well, rare Earth minerals. So the United States actually has an abundant supply.

There have been some shuttered minds in the United States that are now reopening. It's actually a perfect example of the struggle between manufacturing critical components and environmental safety. The environmental safety concerns are abundant.

Actually China is focusing on them and they've expressed concern. I think legitimate concern about health and safety issues associated with production of rare Earth minerals. So it's an issue that the country has to face. I think a decision has to be made to support an environmentally acceptable way for greater production in the United States.

There are also technologies that are in embryonic stage to get away from rare Earth minerals. That is another possible avenue for movement.

I will note however, that for example in the PV industry silicon is manufactured mostly in the United States. We're actually still a leader in poly silicon manufacturing which is in the early stage from raw material to the initial finished goods in the PV value chain. It emerged, of course, in response to the growth of the integrated circuit industry in the 1970s and 1980s. So it's still present here.

One of our portfolio companies will most likely, if all goes well, make a decision to locate their manufacturing facility here of the most advanced silicon manufacturing in the world which will have the lowest cost beating out competitors in China. So it is possible under the right conditions to site manufacturing in the United States that is competitive of the front end materials.

Senator MURKOWSKI. Mr. Chairman, my time is expired. Mr. Coleman wanted to comment. I don't know if you want to allow that.

The CHAIRMAN. Sure, go ahead.

Senator MURKOWSKI. Thank you.

Mr. COLEMAN. I just wanted to add. So I think that as Mr. Auerbach pointed out it is in large part a production issue as opposed to a resource issue. I—but there are some areas where we don't have the resources, but in a lot of areas we do have the resources. We think about it more not just in terms of rare Earths, but also in terms of strategic minerals.

I'll give you just one example. We're an investor in a company that extracts lithium out of geothermal brines. What they've managed to do is figure out how to use the waste stream of the geothermal brine plant and extract lithium, zinc and manganese.

Now lithium is something that we all know is going to be important in our electric vehicle capacity. But typically it comes from either South America or China. With one plant they'd be able to produce 16 percent of the world's supply of lithium.

So there are ways to do it. The challenge for this company is that they're now getting to the point where they're building production facilities. They're actually building a demonstration plant. We haven't been able to necessarily get interest from the U.S. Government in terms of the priority for lithium.

The people who have showed the most interest have been the Japanese. So the Japanese government was actually interested in taking an equity stake in the company. So, you know, I think it's

a matter of whether or not we prioritize these areas and how we think about them strategically and investment.

Senator MURKOWSKI. Thank you.

The CHAIRMAN. Senator Udall.

Senator UDALL. Thank you, Mr. Chairman. Good morning to the panelists.

The CHAIRMAN. Here's the order that I've got here.

Franken, Udall, Shaheen, Stabenow, Manchin, Coons, Cantwell. So if various people come and go that we'll still try to do it in that order.

Senator UDALL. Thank you. Thank you, Mr. Chairman. Again, good morning to all of you.

I wanted to ask you which financing policies that you've seen around the world have been most effective in promoting clean energy development? On that list for me would be things like feed-in tariffs on renewable energy standards, even a price on carbon, imagine that. But before I turn it over to you all I wanted to mention in this spirit a wildly popular program in Colorado. Some of you may be familiar with it.

It's called the Property Assist Clean Energy Program or PACE for short. It's a bipartisan local government initiative that provides a way in which property owners can finance energy efficiency in renewable energy projects for their homes and businesses. Simply, and without any government subsidies, there are some studies that suggest modest implementation of this more broadly would very quickly produce over 100,000 jobs. Then you have the benefits to the homeowners, better cash-flow, reduced energy usage, sustainability, property values are increased.

In my opinion, and I think the Chairman shares this with me because he's a big supporter of this PACE concept, is this gets the government literally out of the way. It leverages the value of that real estate. Then the way in which those loans are repaid is through a lien on the property. I know the Chairman and I really want to see this kind of program expand and succeed.

So in that spirit of what we're doing here would you in turn talk about what you see worldwide as ways that are effective in promoting clean energy development?

Mr. ZINDLER. I guess I'll start off. I think everybody probably got something to say about this.

I would argue that we've not seen a perfect clean energy policy and probably never will. So, you know, all of these should be taken with some degree of, you know, grain of salt. I think if you look in terms of most effective in terms of just spurring very large volumes of deployment the feed-in tariff program in Germany or the one that they had on the books in Spain has been very successful in that regard.

On the other hand when you set a fixed tariff for the amount that you're going to pay for clean energy. You have to be very careful that you set it at a reasonable rate. That you'd be able to adjust it as conditions change.

Because what's happened in Spain and to a lesser extent Germany is they set the rates at a certain amount and then blow that, the cost of equipment just plummeted. Essentially they overpaid.

So that's—that works in terms of deployment. But one has to be careful to make sure that it's not wasteful.

This concept of reverse auctions is an interesting one that Neil mentions. In fact we've seen a few examples of it in Latin America. I mean the way it works down there though is you have a state of grid. Essentially they say, ok, we need 2 gigawatts of wind capacity. We're going to put it out for bid. Then they conduct a reverse auction.

I would say the results so far have been intriguing and not perfect, particularly in Brazil. One of the more interesting things that's happened in the most recent round of auctioning is that developers have come in with what we view are, in many cases, unrealistically low bids. So they come in with a number that they sell. Say they'll sell their power for because they really want to get into the queue. They want to have an agreement signed.

It remains to be seen in Brazil whether or not those projects are going to get built because the economics may not actually work. So I think the key to designing something like Neil is talking about is that you need to put in some kind of penalties for those who bid in at unrealistically low rates. Of course the U.S. policy map has been more of a hodge podge of different kinds of policies. State level, you know, renewable portfolio standards plus a Federal level production tax credit which taken together has, you know, proven to be somewhat effective, but hardly a long term plan and on a per capita basis obviously compared to Germany or Spain or some of these other countries the U.S. has not deployed nearly as much capacity as those other countries have.

Senator UDALL. Ms. Gallagher, did Mr. Zindler leave anything on the table to discuss?

[Laughter.]

Ms. GALLAGHER. Yes. No, I do have a few more comments.

Senator UDALL. Great.

Ms. GALLAGHER. As a Colorado native it's nice to be here before you.

I think that the most important thing we need to bear in mind is that we need market certainty. I mean if there's a common theme I'm hearing here and the one I was trying to make most clear in my testimony it's that in the absence of market certainty whether it's achieved through a feed-in tariff, a renewable portfolio standard or a clean energy portfolio standard, carbon tax, whatever it is. I think there's pros and cons to each of those policy instruments. That will catalyze a market.

I think the finance will come. I do think we have problems with finance in the United States now. But I think the bigger problem is that we don't have some kind of market formation policy that's steady and credible and long term. You know, right now what we have largely are these production tax credits that start and stop.

You compare all the other countries that I referred to and they have set, you know, long term targets and steady, credible policies. You see the results. I mean, they've had good results.

I think one just friendly amendment to the feed-in tariff comment is I think the point he was making was really important. The feed-in tariffs are very attractive because they've proven quite effective in the deployment. But they're very hard to ratchet down.

We should expect that the costs of these technologies will come down with more deployment through learning by doing and so forth.

So I worry about feed-in tariffs from a cost effective point of view. I think the auctions are an interesting possibility or even some kind of tradable permit regime within a portfolio.

Senator UDALL. Thank you for that. My time is expired. I want to stay on the Chairman's good graces. But Mr. Coleman, Mr. Auerbach, maybe you could respond to that question for the record?

So thank you again—actually for the record so we—I will—if you'll do that for the record.

Mr. AUERBACH. Yes.

Senator UDALL. Then my colleagues can continue to ask questions. But thank you.

Mr. AUERBACH. Yes, Senator Udall, I would be delighted also to follow up by providing more information again on the reverse auction concept what Ethan Zindler mentioned about the issues associated with getting it right are correct. I would love to be able to talk with the Senator about how to make that kind of a concept work. It addresses the concerns about overpaying. Lets the market set the standard and increase deployment.

The CHAIRMAN. Senator Shaheen.

Senator SHAHEEN. Thank you, Mr. Chairman. Thank you all for being here.

Mr. Auerbach, you pointed out that in the energy industry only about 0.3 percent is spent on R and D. Can you speak to why that is?

Mr. AUERBACH. Sure. It was a—thank you. It is a report that was produced by the American Energy Innovation Council. So I didn't do the initial research on it. But I do think anecdotally that there are a few reasons why.

First of all, in a commodity market where the consumer does not necessarily know what they're buying it is difficult to express consumer preference in a way that drives behavior to pay for something new. So, you know, in the consumer electronics industry, for example, if I want to spend money buying the IPad 2, even though I just bought the IPad 1 a few months ago, I could decide to do that because I want to buy the features. For electricity I want to have the light go on when I turn on the switch. So there isn't really a consumer preference that drives behavior that encourages adoption of new technologies.

That kind of attitude I think is embedded also in the 50 public utility commissions that govern at State level the regulation of the utility industry. Also I think up until very recently governed the transportation industry. It's changing in the transportation industry. But in the utility industry security and stability of supply are paramount and consumers don't necessarily express their preferences.

What we have now interestingly in the transportation sector now that the customer, the consumer, has been able to get into the act and there's been more competition that has opened up over the last several years. All of a sudden consumers are saying we want electric vehicles. We want hybrids. We're willing to pay more for them.

In the long run you're not going to get mass adoption by paying $15 or $20,000 more per car. But you'll see early adoptive preference which will have its own cascading effect. That's starting to change the transportation industry.

But for the energy industry, it's more difficult.

Senator SHAHEEN. You've all talked about certainty in the market and the need to have demand for new energy technologies. So can you talk about why that's so important if we're ever going to get a robust new energy sector here in this country?

I mean, why does—you referred to it, Mr. Auerbach when you were talking about electronics. We've seen it happen with electronics. We've seen it happen in a number of industries.

So why are we having so much trouble getting to that point in the energy industry? You know, as Senator Udall raised the question about what's most effective. You've thrown out a number of things, but none of them are a magic bullet to getting us where we need to go.

So what do we do to unleash the private sector investment that we all know is so critical and you know that's dependent on American demand. But we haven't seen the demand. So the investment is not there. So how do we get over that hurdle?

Mr. ZINDLER. I think you touch on it just right, Senator which is that the problem has been lack of demand for these technologies to some degree. I mean the stimulus bill, I like to say is probably the most important piece of legislation ever to support the clean energy sector. But the challenge with the bill was that it only focused on subsidizing the supply of clean energy equipment and services. That was a challenge given that the market was not—had a lot of pull on the other side.

So I guess I would argue that the sort of, the simplest top down approach as was mentioned by Ms. Gallagher, some kind of a target. I mean, I know there's been discussion about a renewable electricity standard or a clean energy standard at the State level, these renewable portfolio standards. Something that sets a goal and says, OK we have to get from here to there by a certain year. By the way also includes some kind of penalties for those who do not actually live up to those obligations.

That's, in my mind at least, is probably the simplest way to get about it. But there's obviously a variety of different policies.

Senator SHAHEEN. So, let me just interrupt you for a minute. Would everybody on the panel agree that the single, most critical policy that we could put in place at the national level to move us toward clean energy, is a clean energy standard? I mean, is that what I hear you saying?

Mr. ZINDLER. I guess——

Senator SHAHEEN. Is there agreement on that?

Mr. ZINDLER. I'm not a policymaker. I'll just say what I've seen work have been these kinds of standards in States around the country. Also——

Senator SHAHEEN. Come on. Take a risk.

[Laughter.]

Senator SHAHEEN. You can go for it.

[Laughter.]

Mr. ZINDLER. You're the policymaker, Senator.

Mr. AUERBACH. Do you want someone to second that motion? Is that——

Senator SHAHEEN. I just want, you know, I want to hear what you all think. You're the experts. What's the single best policy proposal we can put in place that would move us in the direction of new energy technologies?

Mr. COLEMAN. I would say it's 2 things. I'm probably going to disappoint you because one isn't going to be that clearly defined which is something along the lines of a clean energy standard. Something that is on the market side that is a long term target that gets mature industries to open up to new technologies.

Because to your point before about R and D. The reason the companies spend on R and D is because they actually either see a competitive threat in the marketplace or they see a massive opportunity.

Senator SHAHEEN. Right.

Mr. COLEMAN. So you see it in drug development all the time because if they develop a drug for a certain disease State then they can go out there and actually capture that whole market. In mature commodity industries that's not the condition. In fact they have a history of swapping IP back and forth in order to, sort of, march down the cost curve together.

So I think you do need some sort of long term policy out there that says this is a national priority. We need to move in this direction. Here are the long term targets. Induce us to move forward in that direction.

I think the second thing is something that actually helps fund the early commercialization of these technologies. I think the challenge there is that when you don't have open markets, when you have markets that are very difficult to penetrate. Then investors are sitting there at that early commercialization stage and saying I'm not so sure that we can come in where the capital intensity starts to ramp up and take the risk that we're actually going to be able to penetrate this market and get down the cost curve at scale.

So you don't see a lot of investment in that space in the clean energy industry. So we do need some sort of entity out there. If you want to attract private capital into that space you do need some sort of entity out there that helps support that.

Senator SHAHEEN. Thank you. My time is out, actually.

The CHAIRMAN. Senator Stabenow.

Senator STABENOW. Thank you very much, Mr. Chairman. Thank you to all of you. I sense a sense of urgency.

I feel it in terms of what's happening in a global marketplace where everyone is running to these new technologies. Doing whatever they need to do to get there understanding that it's jobs. It's innovation. It's creating a middle class from Germany high wage, high regulatory country to China where they said come and we'll build it all for you.

I mean, we're losing to a wide variety of countries that are much more focused on clean energy and frankly manufacturing. Because innovation and manufacturing, commercializing end up together sooner or later. If the idea that we can lose manufacturing and not eventually lose innovation I think is not understanding how all of this works. So thank you to all of you.

We have done some things. But they have been short term. I absolutely agree that we need a broad policy that's in place. We need incentives. We need financing mechanisms. I'm very interested in what you were talking about, Mr. Auerbach, in pursuing that further with you.

We need policies on rare Earth. I want to really complement and associate with our Ranking Member on the rare Earth elements. What's happening in China which is extremely concerning on a wide variety of things whether it's defense, whether it's cell phones or whether it's batteries right now as we are trying to move forward on new electric battery technology and the materials that are caught up in this.

My question though, relates to some things we have begun to do. Batteries being one. I mean, we did put a $2 billion investment into the Recovery Act which has unleashed billions of dollars and new companies in my State and other places.

We're going from according to DOE, 2 percent of the world's battery manufacturing to 40 percent within the next 4 years. That's a pretty big deal if we can keep it going. A123 batteries, Dow Kokum, LG Chem, GM, Chrysler, Ford, I mean I could go on and on with folks that are now investing.

So I'm wondering if any of you would want to respond just to talk about in more detail what kind of impact these kinds of investments can have. Understanding we need a broad policy. We need long term.

But we actually have seen some movement because we've been willing to make some investments to do that whether it's 48C, 1603, whether it's battery technologies. But when we're talking about manufacturing, looking at what we have done in the investment in batteries as well as 48C is certainly having an impact, certainly in my State. So I wonder if you might talk more about the impacts of those kinds of actions.

Mr. Zindler.

Mr. ZINDLER. I guess I'll just make a very quick comment which is I would agree that I think that the advanced vehicle loans at the DOE, has really played an important role in doing a lot of things obviously in Michigan in the auto sector.

Senator STABENOW. Right.

Mr. ZINDLER. I would also say though that as we look sort of further ahead the key is going to be to scale up the number of batteries that are being produced to drive costs down.

Senator STABENOW. Right.

Mr. ZINDLER. This is where we do get back to the question that Senator Shaheen raised about demand. You know, we've looked at the economics of electric vehicles. Generally speaking, not surprisingly, obviously without the subsidies they're not competitive. Then even with the subsidies in some cases it's a tough call for a lot of consumers.

So the question is when those subsidies, the existing credits that are on the books start to run out what happens next to create more demand for electric vehicles so that the battery industry can continue to scale up and drive costs down. So I would say it is—I think it's very good news so far.

Senator STABENOW. Right.

Mr. ZINDLER. But I think there's certainly—there's plenty of, you know, room to go at this point.

Senator STABENOW. But what it relates to also is the ability to have a broader market, right? The ability—and we can help do that by purchasing with the Federal Government. We can do that with the $7,500 credit. We could do that by front loading it, as I proposed and as the President talked about in the State of the Union. So it's more user friendly for consumers because it's at the front end as well.

Ms. Gallagher.

Ms. GALLAGHER. Yes. I just wanted to kind of add another rationale for investment in manufacturing in these advanced technologies. Because as I compare China with United States I think it's important kind of coming back to some of the comments Senator Murkowski made to differentiate between what we're doing well and what China is doing well.

I, having done a lot of research in China over the last decade or so I would say it's clear our technological capabilities are much stronger than China's, with one exception. That would be coal gasification which presents some concern for me. But where China's getting ahead of us is in market share.

So, you know, that relates to jobs, how much are they manufacturing, how many jobs do they have? But over time they will learn and catch up technologically. You know, this whole through manufacturing. They're going to learn a lot.

I think if we're not manufacturing, we're not going to be learning as efficiently as we could. It's going to be hard for us to stay at the cutting edge, at the front the way we should be.

Senator STABENOW. Thank you. I know my time has expired, Mr. Chairman. Thank you.

The CHAIRMAN. Sure.

Senator Manchin.

Senator MANCHIN. Thank you, Mr. Chairman. Let me just say to all of you, thank you for being here today. As you know I come from a State that's an energy producing State. With that a lot of people think that just as coal. Coal is all we do in West Virginia. It's the biggest proportion.

Because—but the other thing is people don't know that we have an energy portfolio. Most West Virginians believe that the most important thing that we can be concerned about is the security of this Nation, being more energy independent. We're so dependent on foreign oil. We see what's going on around the world today.

With that we have to use everything. We don't try to pick winners or losers. We try to use it all.

So we've adopted, 2 or 3 years ago as an energy portfolio standard. We're using everything. We can reduce our carbon footprint by using our coal in cleaner fashion. But it means more investment and we see less investment coming from the Federal Government.

ATL is one of our research lab. We're concerned about that. We do more wind or much more wind than most anyone on the East Coast right now. We're developing it.

We'd love to do solar. We're doing net metering. We net meter back. We're doing everything we can.

With that and there's a lot of comparison to China. You, Ms. Gallagher you talked and Mr. Zindler, you talked as far as economy. Is China using less coal now than they did?

Ms. GALLAGHER. No, no. Of course they're using far more every year.

Senator MANCHIN. Right. Are they over regulating or over legislating their base load coal? Do you see them being more stricter on what they're doing or they're advancing their clean coal technology more rapidly? Because you mentioned it was a concern of yours on the coal gasification why would that be?

Ms. GALLAGHER. I think there's 2 areas in which I think the Chinese are moving much more aggressively than we are.

One is on ultra super critical, very high efficiency coal technology. They have built many, many more ultra super critical plants than we have.

On the coal gasification front the Chinese have similarly deployed far more coal gassifiers than we have. Arguably——

Senator MANCHIN. They're contained to have that in their base load for many, many years.

Ms. GALLAGHER. Yes. Arguably I think that's the one area that I've studied where technologically they have actually, their capabilities are as strong or stronger. They have started to license that technology——

Senator MANCHIN. Would be that because we have put less of an effort for that. We're putting more—and I'm not saying this in any disrespect for—because I think we need it all. But we're throwing all of our eggs in a basket of clean—I mean of renewables.

Ms. GALLAGHER. Renewables.

Senator MANCHIN. Basically which are high priced right now and can't carry a base load. If it wasn't for the credits you're receiving would you all be in business?

Would you be investing in what you're investing in right now, Mr. Auerbach?

Mr. AUERBACH. Without any Federal support?

Senator MANCHIN. Without any Federal support.

Mr. AUERBACH. We would not be investing right now.

Senator MANCHIN. You would not be in business?

Mr. AUERBACH. That's correct.

Senator MANCHIN. Mr. Coleman, would you be in business?

Mr. COLEMAN. We as a firm would be in business, yes.

Senator MANCHIN. But not going—but not investing in, you know——

Mr. COLEMAN. I think that the answer to that is that it depends on the sector.

Senator MANCHIN. So——

Mr. COLEMAN. We have companies that are both solar companies. We have companies that are—we have an underground coal gasification company that actually works on that. The project in Alaska actually that they're working on.

Senator MANCHIN. What I'm saying is if we're going to keep pace with China. It looks like we're using China as the standard bearer right now and what they're doing and how far they're advancing. We know that upstream, the upstream part of energy, coal plants are about 34 percent efficient in the United States.

We've done very little to improve that except for the scrubbers and the low nox boilers. But we have done very little.

We're not going to be able to keep pace at a price that we can compete with. Mr. Zindler, I'd like for you from an economic standpoint.

Mr. ZINDLER. If I could just make one point on, not about the technology but about at least what I perceive to be the Chinese strategy. You're exactly right. They're adding a tremendous amount of coal capacity over there. If you look at the renewable sector and what, you know, if you try to divine what the long term goals are, I would argue that I think the Chinese government views it as a tremendous export opportunity now.

Senator MANCHIN. Sure.

Mr. ZINDLER. That potentially more of a domestic opportunity later. So while China has put in 17,000 megawatts of wind last year, an all time record. They clearly are putting more coal in the ground as well.

They've put very little actual solar, actual generating capacity in the ground in China because they see the export opportunity there. My only point is that they recognize that this is probably one of the greatest economic opportunities of the 21st century and are investing a great deal to try and scale up——

Senator MANCHIN. But they haven't left base fuel?

Mr. ZINDLER. They have not left their base fuel.

Senator MANCHIN. But we are leaving our base fuel and are increasing our prices dramatically.

Mr. ZINDLER. You've officially veered beyond my area of expertise.

Senator MANCHIN. Let me just say this. That I think you know what I'm saying is that we should be having a more robust portfolio than basically picking winners and losers.

Mr. ZINDLER. My view is that, you know, that there's a great economic opportunity in newer——

Senator MANCHIN. Everybody is excited to talk, I can tell.

Mr. ZINDLER. In new technologies. I think that the government, you know, the governments around the world would be well served to make investments in that.

Senator MANCHIN. Yes. I just—I'll finish up real quick. I just want to say that basically I just believe very strongly that we need a balanced portfolio. We need an energy—for a lack of a portfolio we're sitting here trying to pick, OK.

If we give you this you can go in business. But you might not stay. If we don't keep it going you're in trouble.

We should be supporting that by having a good solid base load through this transition period. Do you agree?

Mr. AUERBACH. Senator, not only do I agree. But that was in my opening comments of my oral testimony. I fully agree that the Nation should have a balanced portfolio for energy security reasons.

Ultimately because technologies will leap ahead in different parts of the energy complex at different points in time and that was really the purpose of the chart that I showed. So I believe that the Senators on the——

Senator MANCHIN. One final comment and I'll close real quickly is that I don't know anyone really realizes how much our coal is

being purchased. How many of our reserves are being owned by foreign countries such as China, India, Russia. That scares me to death because some of the best coking coal in the world, we don't own anymore. Other countries own it which makes the best steel in the world.

So I think that we're getting ourselves in serious problems here because we don't have anything to pick up the load. Thank you.

The CHAIRMAN. Senator Coons.

Senator COONS. Thank you, Mr. Chairman. Thank you to the panel for your testimony today. This is, as you can tell, a topic of great interest to many of us even though we have other hearings going on at the same time.

As someone who practiced as In-House Counsel for a global company that was in technology. I'm very concerned about intellectual property. In particular we've had a number of members of the panel here as you questions about China and where we are in terms of our partnerships with them.

We are investing significantly. A main focus of the meetings, between President Obama and President Hu earlier this year was on clean energy collaboration. We've got $150 million joint clean energy research center. We have a U.S./China electric vehicle initiative, a U.S./China renewable energy partnership.

I'm interested in your views on how important these partnerships are. But also how do we do a better job of promoting clean energy research and manufacturing in the United States and of protecting the intellectual property of American companies that are moving to China. The Chinese, my impression from a number of folks I've spoken to, are striking very tough deals where they're offering human capital, property, investment, but largely taking the critical intellectual property of American inventors in exchange for the opportunity to access the Chinese market.

So I'd be interested in what value do you see in these ongoing U.S./China partnerships? What risks do you see in terms of the exposure of critical American intellectual property? What could we do to more effectively defend U.S. intellectual property particularly in the energy space?

All of you if you would, please.

Ms. Gallagher.

Ms. GALLAGHER. Thank you very much.

I'm working on a book on this subject right now. I spent the last summer in China working on 4 case studies specifically examining this question about intellectual property infringement in cleaner energy technologies. I looked at gas turbines, coal gasification, solar PV and advanced batteries.

I have to tell you that I was very surprised by the response that I got. I anticipated hearing that there was significant problems with IP infringement. In dozens of interviews that I did with both Chinese and foreign firms alike, I found no case. I could uncover no case of IP infringement in energy in China which was rather surprising.

So then you might ask, why? How can this be? When you know we know that there's rampant infringement in some industries. I think there's a couple of points I'd make.

The first is that the energy industry is quite different from media or pharmaceuticals where you have—it's very cheap and easy to copy the manufacturing process where as it's actually quite difficult to copy a manufacturing process for an energy technology.

I think second, the government has put a lot of effort. The Chinese government has put a lot of effort into trying to increase its IP protection in this sector because they know they need to get this foreign technology into the market. Most firms I spoke with felt reasonably confident that they'd be successful in a case of IP infringement in the courts in China.

Then the third hypothesis really is that their capabilities are just not very good yet. I think that that's true in every case except for the coal gasification case. But it's notable that in the coal gasification case that that is indigenously developed. Nobody is disputing that.

Senator COONS. Anyone else have a brief comment on that? I've got one more question I'd like to get to, if I could.

Mr. COLEMAN. Just a brief one which is I think that if you look at what's going on in China there was a 2006 report from the Chinese government that coined the term indigenous innovation.

Senator COONS. Right.

Mr. COLEMAN. You know, I think in a double edged sword kind of way, the more you see that the more you'll see respect for IP in this space because they'll have their own IP that they're trying to develop and protect. I think the way that we counter that is programs that help support the national labs and other research and development programs to develop new IP here in this country.

I think RPE is a perfect example of that that helps what has been a very traditional research set of institutions here in the U.S. focus more on the commercialization of some of these technologies.

Senator COONS. Briefly if I could, my other question. In the UK the public sector and the private sector are investing billions of pounds a year in really ramping up for offshore wind, specialized ports, specialized manufacturing facilities, special purpose installation vehicles, training of tens of thousands of workers. The U.S. Department of Energy has a program to invest at most$ 50 million a year in offshore wind development and testing.

Are the current U.S. Federal programs sufficient to induce adequate private investment in the United States to take advantage of what I think is an enormous opportunity, oddly just off the Delaware shores. If not, what Federal policies could we pursue that would be more constructive in rapidly developing what I think is one of our most promising alternative energy technologies for the United States.

Any member of the panel?

Mr. AUERBACH. Senator.

Senator COONS. Sure.

Mr. AUERBACH. Yes, Senator, I'm not going to get in the way of offshore development of wind off the coast of Delaware. So I will support that.

The fact is that in the United States there is such abundant terrain onshore for a cheaper cost to produce wind energy that market forces hopefully will focus first on the cheapest way to access the wind resources in the United States which are most likely onshore.

I'm not sure how much Delaware has onshore. So I'm sorry if I might be putting other States in competition.

But ultimately the approach that I think works for the Nation is to focus on developing its natural resources and commercializing them at lowest cost. So what is happening actually offshore in the UK is good news for Delaware, but perhaps in a different way. What's going to happen is the cost of offshore wind is going to come down over the next 5 years as they scale up massive investments in probably in the hundreds of billions of dollars equivalent offshore.

We're going to get the benefit of that learning as the U.S. develops its offshore wind industry. But now we have the ability to take advantage of great learning curves or progress curves that have taken place onshore in the United States. I would advocate that as a Nation we focus on trying to do, try to utilize the resources that we have and get it out there at lowest cost. That would apply across the board, but particularly in clean energy.

Senator COONS. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Cantwell.

Senator CANTWELL. Thank you, Mr. Chairman, for having this hearing, and thank you to the panelists for being here this morning. I know in your written testimony you talked about providing certainty by eliminating price distortions and by creating new financing mechanisms.

One of the things that was in the last energy bill passed out of this committee, the ACELA bill, was the CEDA bill that both Senators Bingaman and Murkowski provided great leadership on. We want to continue this dialog and consider how we can help with financing of energy projects, particularly given developments in the marketplace in recent years. One of the turnkey approaches that was also included in that legislation was the provision of Federal loans at 1 percent interest, with a payback period of 30 years.

So I'm asking the panelists, does it make sense to harness the government's ability to provide patient capital and provide low interest financing for something as important as this national interest?

Mr. COLEMAN. Do you want to start?

Mr. ZINDLER. If you do deem this to be in the national interest. That developing a new generation of energy technologies is critically important than absolutely I would say that some kind of a program that takes a longer view of this would be very important. In my opening comments I sort of alluded to the fact that the view I see just from the feedback of talking to people in our industry is that the Loan Guarantee Program puts the Federal Government in kind of a tricky position of trying to take very risky bets but at the same time trying to play it safe because that is what they try to do as guardians of the public trust.

I think the idea that's been discussed. I know did pass out of this committee of creating some kind of entity that was sort of at arm's length away from the central function of the government. That may help address this question.

That said that's not intended as a criticism of the Loan Guarantee Program because I think that everybody's probably doing the

best they can with what they've got. It's just that these are difficult circumstance to try and make work as things stand.

Senator CANTWELL. You know, I think of these as actually distinct different things needing varying degrees of oversight and decisionmaking. But the more that government chooses, as opposed to a separate financing mechanism, the longer the approval process is going to take. I would like to see greater opportunities for access to patient capital for financing that a more turnkey financing mechanism can offer, perhaps something similar to what we do with SBIR. What's particularly attractive in this case is the fact that you have a revenue stream from electricity generation.

We've had very good results with the payback of Federal Government loans to small business. But in this case we actually have a steady revenue source through the generation of power, which makes it even more attractive from the standpoint of financial risk to the government. So, Mr. Coleman, do you think it would be good for startups to have access to financing through a mechanism like this?

Mr. COLEMAN. Yes. I think, you know, as I mentioned in my opening remarks I think that the importance of having an entity like this is very high. I think that we need some set of programs that help companies get through what people refer to as the Valley of Death. It is the demonstration/early commercialization point in the development of these technologies in these companies.

Part of that is because there's not yet an open market that's drawing all of the private capital in to actually support these technologies. Part of it is just because the capital intensity at that point for certain types of technologies in certain sectors is extremely high. So I think you mentioned several different options for solving the problem.

I think we need a portfolio of solutions. I think that the thing to focus on, the thing that's really critically important is how do we create mechanisms that are somewhat predictable? So how do we create mechanisms where we, as early stage investors, are saying there isn't necessarily a Valley of Death anymore, right?

We can look at them. We can see that there's a mechanism if we build a certain type of technology. Do a certain performance criteria that we can access in order to get across that valley.

You know, I think one of the challenges has been that when you have spot programs here and there, hard to know whether you're actually going to be able to access them with your company. I think when you have an entity that has—that is defined a certain set of criteria it's much easier to anticipate and therefore easier to invest ahead of.

Senator CANTWELL. Thank you.

Mr. Auerbach.

Mr. AUERBACH. Yes, if I could just add a personal experience from Hudson's portfolio. Fully agree with the statement. We've actually seen it in one of our portfolio companies called Solar Power we recently received a $197 million loan guarantee to site a major manufacturing facility actually in Senator Wyden's State in Oregon in order to build a plant that will manufacture one of the most innovative products in the solar industry.

The CEO of that company that we had recruited had actually been a specialist at building and running plants in South East Asia in other industries. So it was refreshing to see the U.S. Government providing the competitive capital to keep this technology onshore in the United States because other countries were offering similar attractive financing packages. I think that's one other point to make, Senator Cantwell, that other countries are providing those kinds of competitive financing packages to incentivize manufacturing facilities to locate abroad.

Senator CANTWELL. Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Wyden.

Senator WYDEN. Thank you, Mr. Chairman. I want to thank the panel. I'm sorry to have not been here all the time. I heard a little bit in the office and just lots of meetings today.

I want to ask about the global markets as it relates to green energy. I also chair the Trade Subcommittee of the Finance Committee. A number of us are on both this Committee and the Finance Committee. I think clearly there is an intersection.

With renewable energy playing a bigger and bigger role I put a special focus on looking at the practices of China. I'm troubled by a number of them. I organized an effort. Chairman Bingaman was very supportive of this effort that was led by the steelworkers to petition, the trade representative, to look at some subsidies and discriminatory practices employed by China, the World Trade Organization effort led by Ambassador Kirk. Some progress clearly has been made as a result of that.

Certainly there's some indications that China will look at their subsidies as it relates to wind. But I'm of the view that there's a lot more to do. This is not going to go away without some significant and bolder action.

For example China is restricting, in my view, the export of rare Earth minerals. They're doing it for blatantly protectionist and discriminatory, you know, reasons. I think it's going to take a toll. I'm pressing for action on this point.

So the question I'd like to ask, let me pose it to you, Mr. Coleman, if I could. If China played by the rules would this conversation this morning be different?

Mr. COLEMAN. I actually think it probably would. I think that there's 2 answers to your question.

I think the first is that there are a whole lot of structures out there that China leverages that they've given an advantage. I think that the world would be a different place if they didn't necessarily leverage those structures partially because I think we overestimate sometimes the competitive advantage of China. I think we assume too much about lower cost base, you know, lower labor costs, etcetera.

I think if you go and you look at some of these technologies that are being developed both here and in China the costs aren't that much lower at the end of the day. But the government has been a lot more supportive of these technologies.

I think the other side of it is that we could be doing a lot more here. So they've taken a proactive stance on a lot of these things. I think, you know, we can compete with a proactive stance.

Senator WYDEN. I ought to probably quit while I'm ahead. Would any of your contemporaries like to add to that?

Mr. ZINDLER. I guess I'll wade in carefully here. Just say that I don't think—I think that most of the Nations in the world that are very involved in clean energy in one way or the other have some kind of policies in place to help their domestic industries. That has included Canada which has domestic content requirement. It includes the United States which imposes a tariff on imported ethanol from Brazil and other countries. So I think we need to look at this a little bit holistically in that it's not one country alone that's involved in this.

I'd also really endorse Will's point which is that, you know, China has scaled up by making commitments of unprecedented amounts of capital. That that's really in many ways helped it get, I would argue, helped it get more of a lead than whatever kinds of trade policies that they have put in place to date. So I think it's important to keep focused on what it is that's really allowed that country to flourish in terms of attracting clean energy investment as opposed to other Nations.

Senator WYDEN. I don't think there's any question that there are others that are part of these practices. That this is a global kind of question. I think the Chinese have taken this to a very different, you know, level, particularly the speed with which they move to protect rare Earth minerals I think is a signal of what this is really all about.

They saw that this was going to be enormous ramifications for key, you know, industries, electronics and others. They moved so rapidly. I think is reflective of why I've been concerned throughout my time in public service.

I voted for every market opening, you know, agreement that we've had. In my youth I was a member of the House as well. So we had a number of these there. I think this challenge is very, very different.

My time is about up. Would any of—Mr. Auerbach, would you like?

Ms. GALLAGHER. If I could just make one comment which I tried to emphasize on my testimony. I think the market access issues are very serious in China. As we look forward to China being by far the largest market in energy, period, for the next 2 decades. This is something we really need to focus on.

I'm less worried about some of the issues you've raised than I am about procurement, I guess, if I had to say it specifically.

Senator WYDEN. You're going to hear me say in a little,—my time is up. You're going to hear me say a little more about procurement because it is absolutely outrageous that the Chinese have said again and again that they would not engage in these practices indigenous innovation and these others that are just blatant, you know, protectionism and yet one offer after another sort of goes by the boards. So I'm going to have a little more to say about it in the days ahead.

The fact that they are engaging in those practices in an area particularly with digital goods and the like is going to take a very substantial toll on our trade relationship. For those of us who want market opening agreements, their unwillingness to move on the

procurement issue is going to harm our relationship. I want to see that change. I'm going to press hard to do it.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you. Let me just ask Mr. Coleman a question here to clarify my understanding of what you're saying.

You're indicating that, as you say, the problem is not that we can't innovate it's that getting the innovation that we do adopted, particularly in the electric sector. There's a problem there. The problem there, of course, is because electricity is produced and distributed by utilities which are in most cases are regulated by public utility commissions in the various States.

As you say there is not appetite for risk. No incentive to take any risk. Everyone is just happy as a clam. So there's no reason to do anything innovative.

The way to break out of that, as I understand what you're suggesting is that we need some kind of incentive to be imposed or some kind of requirement to be imposed, hopefully on a national basis. Something like a clean energy standard or something which would require utilities to go ahead and take some chances and actually welcome some innovation in this clean energy space and in the area of energy efficiency. Now is that a fair statement of what you're talking about?

I mean, I guess the one point I want to just be real clear on. The bureaucratic regulation which you referred to, is not just a problem with the government. It is a problem with these very large incumbent utilities which obviously are the only game in town if you want to buy electricity when you plug in your lamp.

Is that fair?

Mr. COLEMAN. Yes, I think that is fair. I think that the—but there's a couple different components to it. So I think that on one end it's a clean energy standard or something to that effect which actually sets a target. Not only would it push the utilities and public utility commissions to think about new technologies in terms of meeting that target. But it would actually give a signal to the market to invest in some of those new technologies ahead of the horizon.

But the other component of it is also some of the ins and outs of developing the next generation of grid technologies. Some of that can be brought on board by a standard that drives energy efficiency and what not. Some of it is also operational efficiency and taking risk on some of the grid technologies that have already been developed out there.

I think part of the challenge is that we, you know, the States drive a lot of this. But those markets are very fragmented. When you're looking at a technology, developing a technology or investing in a technology, it's hard to know whether if you're successful getting through to public utility commission in one State whether or not you'll get through that public utility commission in another State. So the market ends up being one fiftieth and in many cases even smaller than that of what it could be here in the U.S.

So that creates friction. Iit creates obstacles to us actually wanting to invest. So I think there's 2 things.

One is the clean energy like standard.

The other is some effort by the Federal Government. I don't know whether that's something that comes out of the Senate or the House or whether it's something that comes out of the Executive branch, to try and align some of these public utility commissions around adopting new technologies in a more accelerated fashion.

The CHAIRMAN. Alright.

Mr. Auerbach, did you have a comment on that?

Mr. AUERBACH. Yes, thank you, Senator. I'd like to just respond by also combining the observation made by Senator Murkowski. If you actually look at the States as the laboratory for how these policies actually play out at a State level you find that almost all of the investment in clean energy deployment has occurred in States with renewable energy standards.

But also even if you have those standards, if you don't have a permitting environment that recognizes the need for environmental stewardship and also for safe commitment of capital you run into problems. It's notable that over the last 5 years that Texas, in which it is easier to permit, to gain permits for installing wind farms, has leapt ahead of California as the Nation's leading place for wind turbine installation. It's also now one of the most active or not the most active State in the country for installing new transmission to accommodate all these resources.

California, although they have the most ambitious renewable portfolio standard in the Nation, has lagged behind because of permitting obstacles on a relative basis compared to Texas. So as we look at a Federal level of how to actually get this right, I think learning some of the lessons of the States. Trying to encourage the adoption of policies that streamline the permitting process that allow all the relevant parties to have a voice but to put more accelerated time limits so that business can be concluded and capital could be deployed will make it safer for risk capital to come into those States and into the Nation.

The CHAIRMAN. Senator Murkowski.

Senator MURKOWSKI. Thank you, Mr. Chairman. Just one final question and this relates to the subsidies. Because it would appear that when you look to those countries around the world that seem to be leading when it comes to the clean energy investment, they also appear to be leading in the category of subsidies as well.

So the question and I throw it out to all of you is whether or not this is a sustainable policy for us is does it bring the most efficient, the most effective technologies to market. We're at a time when we are looking at budgets. We're pretty quick to pick winners and losers through the budgetary process.

From the investment side of things I know one of the things that I hear as I'm talking to folks is you don't give us any level of predictability with the subsidies that are out there. They are shorter term. They get caught up in the politics of what goes on here in Washington.

So the question is is how sustainable is that? Is that the most effective, efficient way for us to advance these technologies? I throw it out to all of you.

Mr. AUERBACH. Senator, if I could just start by saying in my written and oral testimony I addressed that question. I think it's

a very important question. In my opinion the Nation needs a balanced portfolio.

What we have seen over the last 10 or 20 years is remarkable progress in reducing costs across a wide variety of clean energy technologies. From where I sit I see those trends as continuing quite aggressively. So that by encouraging capital formation and deployment in this country ultimately what we're investing in. I know it involves spending money, but not necessarily depending upon how you design it, is actually not just a cleaner energy future, but also a lower cost future.

So policies that promote a diversification of approach and then also the investment behind risk capital that is really deployed by folks like us, like Mohr Davidow and others is a smart approach for the United States to be encouraging lowest cost solutions over the course of time.

Senator MURKOWSKI. Mr. Coleman.

Mr. COLEMAN. Yes. I want to echo what Mr. Auerbach has said which is that I think that we need to be careful about not looking at just a snapshot in time which is really where we are today. I think we run the risk if we do that of sort of stepping over dollars to pick up a penny, if that makes sense.

I think we're in budget constrained times. We think about subsidies and the cost and that's very appropriate. The question is where we're going to get to in 5 to 10, 15 years on these technologies and their costs.

I think that the chart that was put up earlier showed the way that these cost curves have pretty steep declines. They've shown incredibly steep declines as they've scaled. Now much more rapid declines than when we've scaled some other technologies.

So I think we have to think about how we can get to a lower cost base on an unsubsidized basis going forward. If subsidies are one of the things that drive us to that point so that we can manufacture those technologies here and we can deploy them here, then I think we need to consider those as an option. You know, but I think we should be focusing subsidies on those technologies that can actually get there not on technologies that will never get there.

So that's the challenge that we face which is how do we decipher which of these technologies we should be focusing on and which ones we should——

Senator MURKOWSKI. Are we the ones that are in the best position to make that determination? Last I know there's not too many of us here in the Senate that are either scientists or those that are involved in developing these technologies. But we pretend we are.

Mr. Zindler? Ms. Gallagher? Any comments on the subsidies?

Ms. GALLAGHER. I think that that's just one tool in the tool box. I would argue we need a broader set of tools. The other point I'd make is that subsidies shouldn't last forever.

The point I've been trying to make is I do think we—I think there's a role for subsidies. But we should make clear that they will decline over time. That there's nothing wrong with saying you can count on this for a certain period of time and then a lower subsidy and then eventually they'll end.

There is evidence for that. Brazil is an excellent case of they do not subsidize their sugar cane ethanol anymore and they're market

competitive. So I think, you know, there's lessons we can learn about how to ramp those down over time. We should start doing that.

Senator MURKOWSKI. Mr. Zindler.

Mr. ZINDLER. I guess that there's not too much that—I basically agree with almost everything that was said here except for I would just say is that there's some—there is always the question of how much does it cost to do nothing. You know, every year, you know, companies across the U.S. spend millions, billions of dollars on trying to hedge the price of coal and natural gas and other fuels. So is that real value that's being spent right now. Is there a way to eliminate that if you can lock in over the next 20, 25 years exactly how much it's going to cost to provide a megawatt hour of electricity. What is the value of that to the U.S. economy?

I would argue that that should be part of the conversation as well.

Senator MURKOWSKI. I appreciate the comments.

Ms. Gallagher, I particularly appreciate yours. That we shouldn't be afraid to phase these out, to be up front, to be transparent to give some predictability within the industry as to how long these are going to be here. Rather than just leave them to the political whims of one Administration coming in from an investment perspective we don't do much to help to facilitate it when we can't give those indicators that you can rely on.

I think part of the problem that we face is we start with the subsidies and then people become very attached to them. In representing our constituents that have gotten attached to them it's difficult to undo them. We have subsidies in place that we probably don't even know are still out there. We're paying for them.

The real question is is how effective, how efficient are they really in the process that we're all trying to advance?

Mr. Chairman, I appreciate the time and the testimony from the witnesses today.

The CHAIRMAN. Thank you.

Senator Shaheen.

Senator SHAHEEN. Yes, thank you.

I wanted to get into one area that hasn't really come up very much in discussion today. There's been a lot of talk about China and the investments that China is making in various sectors. But nobody or at least, I didn't hear anybody mention carbon capture as part of that discussion.

It seems to me that that's one area where it's going to be very important for us to think about how we might compete. I speak from a very parochial perspective because we have a company in New Hampshire called Powerspan that's working on this technology and is making some real progress. But can any of you talk to what kind of investments China is making in carbon capture and whether there are any projections for how long it will take them to get to real commercialization or whether the prospects to get there are good?

Then how competitive technologies here in the United States might be with what China is doing?

Ms. Gallagher.

Ms. GALLAGHER. Yes. I think there's 2 points I'd like to make about China.

First, they came very late to carbon capture.

Senator SHAHEEN. Right.

Ms. GALLAGHER. They only recently decided to start investing. The Minister of Science and Technology only recently started to support carbon capture and storage technologies. However, although they came late they're now moving fast. I think you can actually attribute that to the leadership within some of their leading firms.

So Huaneng, for example, which is the main builder of the GreenGen plant, has already piloted demonstration projects for post combustion carbon capture which I know is Powerspan's technology too. Through the GreenGen Project they'll be doing a number of demonstrations on pre combustion, Shen Hua also moving very aggressively on carbon capture pilot as well. So I think this is one area where we're starting to fall behind.

I also think this is one area where there's potentially a lot of—it would be interesting to explore the possibility of joint demonstration projects. The reason for that is that carbon capture and storage is still very expensive. It's—we're way pre-commercial at this point. But we all need to learn more about this technology. By pooling our resources we could share those risks and share those costs. I think this would be a really promising area for future U.S./China cooperation.

Senator SHAHEEN. It's interesting. I'm sure you all saw the James Fallows article in the Atlantic in December where he proposes that exact idea. Suggests as you have that this is a place where there might be a real opportunity for cooperation that would benefit us both.

Anybody else want to comment on that?

If not, I would just say the other place where I think there is an opportunity for us to encourage not clean energy technologies, but energy efficiency through policy changes. You were talking about Texas, I think, Mr. Coleman or Mr. Auerbach. I'm—they were the first State in the country to put in place an energy efficiency standard which I would guess has had something to do with some of the energy progress they've made.

So that's another area where I think there's real opportunity for us because it's the cheapest, fastest way to deal with our energy needs. So, thank you all.

Thank you, Mr. Chairman and Senator Murkowski.

The CHAIRMAN. Senator Murkowski, do you have any other questions?

Thank you all very much. I think it's been a useful hearing. Yes, we appreciate it.

[Whereupon, at 11:26 a.m. the hearing was adjourned.]

APPENDIX

RESPONSES TO ADDITIONAL QUESTIONS

RESPONSES OF NEIL AUERBACH TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. You mentioned several companies that, though based in the US, have taken advantage of incentives to move production overseas, where I imagine much of this manufacturing is automated. Given the fact that this results in low cost end products, should we be concerned if the manufacturing isn't in the US? What effect does this have on the competitive landscape—particularly when it comes to the next generations of these technologies?

Answer. Chairman Bingaman, the US should be focused on increasing its share of manufacturing in the renewable energy supply chain to promote US competitiveness, increases domestic jobs and create wealth that grows our GDP and reduces our trade deficit.

Our international trading partners—led by China—are laying plans for massive investments in the clean economy. The clean energy market is forecast to triple in size during this decade, from $740 billion in 2009 to over $2 trillion by 2020,[1] exceeding global GDP growth even under the most conservative growth scenario and annual capital invested in additions to clean energy generation capacity is already pulling even with fossil fuel generation capacity.[2] The vibrant markets for clean energy and energy smart technologies, such as smart grid, ultra high capacity transmission, advanced energy storage, LED lighting, and electric vehicles, will be dominated by countries encouraging investments in R&D, manufacturing and deployment. In 2010, the U.S. accounted for 14% of the clean energy market, but its pole position fell for the second year in a row. Germany and China accounted for 17% and 22% respectively in 2010, taking the number one and two positions, which belonged to the US in the two years prior.[3] Further, the United States lags our trading partners in terms of clean energy manufacturing capacity. For example, only 6% of worldwide PV cell production takes place in the United States while 59% of global cell production takes place in China.[4] And, in terms of clean energy deployment, the US leadership has begun to wane. For example, in 2007, the United States installed nearly 6GW of renewable energy capacity, approximately 60% of all domestic newly installed power generation capacity[5]. China, by contrast, installed less than 5GW[6] of renewable energy capacity, approximately 6%[7] of its newly installed power generation that year. Just 3 years later the picture changed dramatically. In the United States, only 5GW of renewable energy capacity was installed in the United States, whereas nearly 17GW of renewable energy capacity was installed in China.[8] Over the same period, China moved up the league tables of top ten manufacturers of wind turbines and solar panels (See *Figures 2 & 3).

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[1] HSBC Global Research, "Sizing the climate economy", September 2010

[2] Bloomberg New Energy Finance: annual capital invested in additions to clean energy ($187bn) and fossil fuel generation capacity ($219bn)

[3] Bloomberg New Energy Finance and Pew Charitable Trust "Who's Winning The Clean Energy Race? 2010"

[4] Solarbuzz (data includes Taiwan) http://www.solarbuzz.com/our-research/recent-findings/solarbuzz-reports-world-solar-photovoltaic-market-grew-182-gigawatts-20

[5] U.S. EIA—Electric Net Summer Capacity http://www.eia.gov/cneaf/alternate/page/renew___energy___consump/table4.html

[6] Bloomberg New Energy Finance Database

[7] Reuters: China installed capacity hits 710 GW in 2007 http://uk.reuters.com/article/2008/01/09/china-power-capacity-idUKPEK24321320080109

[8] Bloomberg New Energy Finance and Pew Charitable Trust "Who's Winning The Clean Energy Race? 2010" Total installed renewable capcity: US (58GW) China (103GW)—http://bnef.com/WhitePapers/download/36

* All figures have been retained in committee files.

To be competitive, the US must not just maintain its edge in R&D investment, but focus even more on encouraging the growth of manufacturing and deployment at home, as are other countries around the world. America is not predestined to remain home to the most vibrant economy in the world forever. We need to rise to the challenge.

While striving to improve our global competitiveness, we must also address our most immediate concerns at home: creating jobs and reducing the cost of energy. Investments in clean energy today can support a 21st century industry in the United States and foster productive job creation as the country diversifies its energy mix. Interestingly, despite the recession, we are expected to see 143,000 jobs created in the wind industry and 58,000 jobs created in the solar industry.[9] Two of our trading partners, China and Germany, boast even more jobs in their home markets. China estimates that it employs approximately 1.4 million people in the clean energy sector.[10] Germany, on the other hand, estimates that it employs approximately 370,000 people in their clean energy sector.[11] A focused effort on making the United States a more welcome home for clean energy manufacturing and deployment can result in even more job creation here at home.

Many people mistakenly believe that wind and solar, as well as other forms of clean energy, are interesting technologies that may become scalable and affordable in the future if we make sufficient progress on the technology front. This is a serious error. More solar energy capacity was installed in 2010 around the world than nuclear power.[12] The cost of solar energy today is cheaper than the cost of nuclear energy from a Gen III nuclear power plant.[13] The pace of annual solar installations around the world will have increased nearly fifteen fold between 2005 and 2011, and installations are forecast to double again by 2015.[14] Costs of wind and solar energy have come down almost as quickly as the scale of the industries has increased. The history of the power industry reveals that all new energy sources start out expensive, and get cheaper with scale. Wind and solar are following suit today, and at a pace even more dramatic than coal, natural gas or nuclear did in their day. The cost of wind power, for example, has fallen by 30% over the past 3 years.[15] Recent anecdotes suggest that in some markets, wind power is now cheaper than power generated from a combined cycle gas plant (CCGT). The progress of the solar industry in reducing costs is even more impressive. The cost of solar power has dropped approximately 15% per year over the past several years, and is expected to continue. On the current pace of cost reduction, solar energy may be cheaper at distributed generation scale in many markets than power generated by fossil fuels within 5 years.[16]

The following chart, which was produced by my colleagues for an article published in the Journal of Environmental Finance,[17] catalogues the history of price movements of electricity powered by coal, natural gas, and nuclear energy since 1930. History teaches us that each of these power sources has required achieving massive scale in order to achieve their current favorable cost structures. Hudson's research confirmed that small increases in scale are causing significant improvements in the cost structures of the wind and solar industries. Figure 4 clearly demonstrates that wind and solar energy have reduced costs more rapidly than any other type of conventional energy source over the last 80 years.

The rapid reduction in clean energy's cost structure is projected to continue, and will bring these technologies into grid or retail parity with conventional power sources over time, even cheaper than conventional power sources in more and more markets over time.

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[9] Lawrence Berkeley National Laboratory (LBNL) and The National Renewable Energy Laboratory (NREL)

[10] NY Times: "China Leading Global Race to Make Clean Energy" http://www.nytimes.com/2010/01/31/business/energy-environment/31renew.html

[11] Gross employment from renewable energy in Germany in 2010 http://www.bmu.de/files/english/pdf/application/pdf/ee___beschaeftigung___2010__en__bf.pdf

[12] The World Nuclear Industry Status Report 2010-2011, Draft Version—2010: 5GW of nuclear reactor startups http://www.worldwatch.org/system/files/NuclearStatusReport2011__prel.pdf

[13] "Solar and Nuclear Costs—The Historic Crossover"—Solar (14-18 cents/kWh) vs. Nuclear (20 cents/kWh) http://www.ncwarn.org/wp-content/uploads/2010/07/NCW-SolarReport__final1.pdf

[14] Photon Consulting Database: 2005-2011 annual installations (1.8GW to 27GW); 2015 (51GW annual installation, 225GW total installed)

[15] Hudson estimates

[16] See comments of Mark Little, research director of General Electric, reported in http://www.bloomberg.com/news/2011-05-26/solar-may-be-cheaper-than-fossil-power-in-five-years-ge-says.html

[17] Environmental Finance, "Making the Case for Clean Energy", December 2010–January 2011

Question 2. Many of the technology leaders of today, design products and hold intellectual property in the US, but build their products overseas. Is there something different about the clean energy industry that makes this less likely to happen? How do we insure that manufacturing won't eventually move offshore as support is inevitably phased out over time?

Answer. Chairman Bingaman, the U.S. has been a global leader in inventing the clean energy products that the world is currently using, and that leadership position, while threatened, has not yet been lost.

The renewables energy industry relies heavily on large capital equipment. Due to the capital intensive nature of this business, supply chains tend to organize themselves close to end-use markets so as to most efficiently accommodate and serve customers. The US is one of the largest end use markets for energy consumption and already has a well organized supply chain. We've seen many foreign companies, such as Vestas, Gamesa, LM Glasfiber, Mitsubishi, Kyocera, REC, and Sanyo build factories in the US to serve our wind and solar markets. Going forward, however, without a strong and visible commitment to support the US clean energy market through its maturation, the United States will not only risk losing its technology edge but foreign companies will also no longer commit capital to the US.

We've seen evidence that industry leaders naturally want to own pieces of market share along different parts of the supply chain in the US to optimize their own logistics, manage currency risk, and take advantage of both state and federal incentives. However, the threat of market contraction in the US will cause our existing supply chain to contract as both domestic and foreign companies downsize. Therefore, in order to ensure that manufacturing won't eventually move offshore, our national goal should be to cultivate a strong and robust domestic market so that the supply chain continues to develop in a way such that it can provide the least expensive and best quality products to the market. Without a robust domestic market, our trading partners will seize on the wavering of our resolve and grab the mantle of clean technology leadership to the benefit of their citizens and public wealth.

RESPONSES OF NEIL AUERBACH TO QUESTIONS FROM SENATOR COONS

Question 1. Several major policy think tanks (the Bipartisan Policy Center's American Energy Innovation Council, Third Way, and others) have suggested investing at least $15 billion in federal funding for clean energy as a benchmark to target for the U.S. staying competitive. This would support the government's partnerships in innovation with the private sector, and help give the private sector greater access that it needs to develop, deploy, and commercialize clean energy technologies? Is this realistic given other nations' investments?

Answer. Senator Coons, it is my understanding that the policy recommendation to which you refer calls for $16bn of investment on an annual basis, specifically towards energy RD&D to support the government's partnership in innovation with the private sector[18]. A report published by the American Energy Innovation Council highlighted that the US spends the least amount of its GDP on energy RD&D (0.3%) relative to its trading partners China (0.4%), France (0.5%), Korea (0.6%), and Japan (0.8%)[19] Germany, for example, single handedly catalyzed the global growth that we've seen over the past 6 years in the solar sector. As a result of the country's targeted and steady R&D spending in the early half of the decade,. More domestic innovation will help keep our country competitive in this vital sector and clearly the US should be investing more than it is currently. However, rather than debate about whether the figure you've quoted is an appropriate benchmark, perhaps I can point out some of the governmental support being provided to the world's two largest clean energy markets, Germany and China, in an effort to improve their global competitiveness.

Germany, for example, single handedly catalyzed the global growth that we've seen over the past 6 years in the solar sector. As a result of the country's targeted and steady R&D spending in the early half of the decade,[20] followed by strong political support for the sector in the latter half of the past decade, via its renewable energy Feed-in-Tariff, Germany has nurtured the growth of the solar industry and established a robust domestic market, spawning globally competitive companies,

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[18] Americans for Energy Leadership: http://leadenergy.org/2010/06/news-american-energy-innovation-council/

[19] "A Business Plan for America's Energy Future"— American Energy Innovation Council: http://www.americanenergyinnovation.org

[20] "Evidence from RD&D spending for renewable energy sources in the EU" Ragwitz, Mario and Apollonia Miola; Fraunhofer Institute for Systems and Innovation Research: http://www.scribd.com/doc/7311594/Evidence-from-RDD-spending-for-renewable-energy-sources-in-the-EU

such as Wacker Chemie, Roth & Rau, Schott Solar and Q-Cells. To facilitate the country's exports, the German Federal Government provides export credit guarantees to protect exporters against economic and political risk in countries purchasing German products. And to further support the country's developers outside of the country, Germany's development bank, KfW, has been one of the largest financiers of renewable energy projects around the world, having committed almost 25% of the bank's capital, ~€6bn over the past 5 years[21], to renewable energy. This combination of early stage research, domestic demand-side policy support and export driven financing support helped Germany create nearly 370,000 clean energy industry jobs[22] and attract roughly $41bn worth of investment in clean energy in 2010, $7bn more than the US.

China, on the other hand, began to implement clean energy policy support mechanisms in the middle of the past decade in an effort to catch up with the rest of the world and attract investment to their power hungry country. and attract roughly $41bn worth of investment in clean energy in 2010, $7bn more than the US. [23] Recently the country announced seven strategic emerging industries in its 12th five-year plan that it intends to have account for 8% of total GDP by the end of the decade. Five of those sectors involve clean energy technologies. Additionally, China has begun to build its first of what are likely to be many billion dollar clean coal plants that utilize new carbon capture and storage technology. It would be risky for us to assume that we will maintain a meaningful share of the worlds clean energy supply chain when China, for example, last year installed 17GW of wind capacity whereas the US, by contrast, built just under 5GW[24]. In 2011, China is projected to install over 21GW of additional wind capacity and the country has goals to build at least 70GW of new wind and 5GW of new solar capacity within the next three years.[25] As a testament to China's commitment to clean energy development, China Development Bank (CDB) lent over $35bn to its clean energy sector during 2010, up 30% from the previous year, to strengthen the country's competitiveness. Similar to Germany's strong political support for this sector, China's continued dedication to its domestic clean energy development is attracting both the supply chain and the focus for innovation.

The US has not yet lost this race with our global trade partners, however, we must recognize where our relative strengths are and leverage them in an effort to remain competitive. The United States has the most robust capital markets in the world that are driven by the private sector. These markets can be mobilized in partnership with the government to continue supporting clean energy innovation in the US. In order to give the private sector the access that it needs to develop, deploy and commercialize clean energy technologies, there must be a strong and continued policy commitment, which we haven't had to date. Though China and Germany are currently leading the world in clean energy investment and have developed more robust supply chains to support this industry, the US still has an opportunity to build a more competitive market and both the federal and state governments have a pivotal role to play in partnering with the private sector to see this through.

Question 2. There are many programs in place in the federal government. Many are programs that are likely not widely known like the Navy's ocean and wave energy program. Others are popular and high profile—DOE's weatherization or EPA's Energy Star programs. We want government to work more effectively with the states and private sector in this area. In part, this is an issue of good communication and coordination. Funding is important, but should also ask if some of these federal programs are effective or redundant?

a. Follow up: Do we need new models (programs like ARPA-E and Energy Hubs) to focus federal investments to areas of greatest need?

b. Follow up: Are there areas where the federal government is lacking, where there are major gaps that the private sector and entrepreneurs are not utilizing?

Answer. Senator Coons, the private sector does look to both the armed services and energy departments for leadership, guidance and partnership in energy related activities. Solazyme, for example, is a company that provides algal-based biodiesel and jet fuels to the US Navy in a partnership that is helping the armed service division achieve its goal to create the Great Green Fleet by 2016. The effectiveness of

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[21] Bloomberg New Energy Finance Industry Intelligence Transaction Database

[22] "Gross employment from renewable energy in Germany in 2010". Report commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, March 2011.

[23] "China's first clean coal plant underway".http://www.tpri.com.cn/eng/index.htm

[24] Bloomberg New Energy Finance Industry Intelligence Transaction Database

[25] Bloomberg New Energy Finance Insight

this and other programs and directives should be judged based on their respective metrics for success.

The need for government programs to foster early-stage energy technologies is largely rooted in the power industry's failure to reward private research and development activity. R&D spending in the energy industry overall as a percentage of sales, 0.3%, is the lowest of all major technology-dependent sectors, such as the automotive (2.4%), computers and electronics (7.9%), aerospace and defense 10 (11.5%), and pharmaceuticals sector (18.7%).[26] The heavily regulated power sector is structurally risk averse and programs, such as ARPA-E, should exist to address this market failure in an effort to enhance US economic security and ensure that the US remains a technological and economic leader in developing and deploying advanced energy technologies. There is strategic value in addressing this early-stage research and development funding gap created by the market failure in the power industry with programs that attract liquidity to grow these new markets that would otherwise fail as a result of underinvestment.

Question 3. According to the Pew Charitable Trusts, jobs in clean energy sectors grew two and a half times faster rate than jobs in the economy as whole between 1998 and 2007. Furthermore, an analysis by the University of Massachusetts, Amherst revealed that investments in clean energy could create 1.7 million net new jobs in the next ten years. Some have talked about all the jobs in the traditional energy industry. Can you comment about the potential for these clean energy jobs as factor in economic recovery?

Answer. Senator Coons, reputable studies showing positive job growth in the clean energy sector are mounting. In fact, Brookings recently released a study, "Sizing the Clean Economy: A National and Regional Green Jobs Assessment" and concluded the following data points[27] relevant to jobs and economic recovery:

- The clean economy, which employs some 2.7 million workers, encompasses a significant number of jobs in establishments spread across a diverse group of industries.
- The clean economy grew more slowly in aggregate than the national economy between 2003 and 2010, but newer "cleantech" segments produced explosive job gains and the clean economy outperformed the nation during the recession.
- The clean economy is manufacturing and export intensive.
- The clean economy offers more opportunities and better pay for low-and middle-skilled workers than the national economy as a whole.
- Among regions, the South has the largest number of clean economy jobs though the West has the largest share relative to its population.
- Most of the country's clean economy jobs and recent growth concentrate within the largest metropolitan areas.
- The clean economy permeates all of the nation's metropolitan areas, but it manifests itself in varied configurations.
- Strong industry clusters boost metros' growth performance in the clean economy.

As a policy recommendation, the study suggested a few points[28] to catalyze faster and broader growth across the U.S. clean economy:

- Scale up the market by taking steps to catalyze vibrant domestic demand for low-carbon and environmentally-oriented goods and services.
- Ensure adequate finance by moving to address the serious shortage of affordable, risk-tolerant, and larger-scale capital that now impedes the scale-up of numerous clean economy industry segments.
- Drive innovation by investing both more and differently in the clean economy innovation system.
- Focus on regions, meaning that all parties need to place detailed knowledge of local industry dynamics and regional growth strategies near the center of efforts to advance the clean economy.

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[26] "A Business Plan for America's Energy Future".American Energy Innovation Council: http://www.americanenergyinnovation.org

[27] "Sizing the Clean Economy: A National and Regional Green Jobs Assessment" http://www.brookings.edu/reports/2011/0713__clean__economy.aspx

[28] "Sizing the Clean Economy: A National and Regional Green Jobs Assessment" http://www.brookings.edu/reports/2011/0713__clean__economy.aspx

RESPONSES OF KELLY SIMS GALLAGHER TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. One particular concern you voice about US policies with regard to clean energy is the significant changes from year to year. Is that more a function of shifting priorities in which technology is being supported, or is support fluctuating across the board?

Answer. When I made that comment, I was mainly thinking about the policies that the U.S. government employs to support the deployment of cleaner energy technologies, and in particular our various tax policies. The production tax credits, investment tax credits, income tax credits all have proven relatively unpredictable. But, it is also true that our level support for RD&D is inconsistent, both within technology programs, and as measured as a total amount of dollars invested. I've attached a graph* from a database that I maintain on the DOE ERD&D budget, which shows the volatility as Appendix A here.

Question 2. You found that developing countries are significantly out-investing developed countries such as the US in clean energy. Can you break this down with regard to what part of the innovation process these investments are targeting? Is there a particular place where the US is falling further behind?

Answer. Yes, in a recent paper my co-authors and I found that the major emerging economies were outspending OECD countries in energy RD&D. One important difference between these BRIMCS countries (Brazil, Russia, India, Mexico, China, and South Africa) and the United States, however, is the large prevalence of state-owned energy (SOE) companies in the BRIMCS countries. We include the expenditures of SOEs in our estimates, and that is one reason why their investments are so large. China's investments account for about 85% of the BRIMCS country government investments. Chinese investments are mainly in fossil energy technologies, and they appear to be 10 times larger than U.S. fossil investments. We do not have good enough data to be clear about how much of this investment is in research vs. demonstration so more analysis is needed.

Question 3. You mentioned, and Senator Machin highlighted, that China has actually taken the lead in development and deployment of clean coal technologies, including high-efficiency boilers and the like. Can you outline the policies China has in place in this area that are likely spurring their technological advance? What can you tell us about the regulatory environment in China for coal-fired generation?

Answer. China is far advanced in the demonstration and early commercialization of advanced coal technologies, especially for coal gasification and ultra-supercritical coal. As I'm sure you know, China is on track complete its GreenGen project, which was inspired by the original FutureGen, well in advance of the current FutureGen program. In addition, the central government is now considering approval of 5-10 new integrated CCS projects.

RESPONSES OF KELLY SIMS GALLAGHER TO QUESTIONS FROM SENATOR COONS

Question 1. Several major policy think tanks (the Bipartisan Policy Center's American Energy Innovation Council, Third Way, and others) have suggested investing at least $15 billion in federal funding for clean energy as a benchmark to target for the U.S. staying competitive. This would support the government's partnerships in innovation with the private sector, and help give the private sector greater access that it needs to develop, deploy, and commercialize clean energy technologies? Is this realistic given other nations' investments?

Answer. My own opinion is that we need to be spending much more than we currently do, but whether or not $15 billion is the correct figure is anyone's guess. I would advocate spending more on clean energy demonstration and early deployment rather than R&D simply because we already have many cleaner technologies ready to go that are failing to penetrate the marketplace due to higher costs. Removing subsidies from fossil fuel production would be one way to free up funds for cleaner and more efficient energy technologies. Imposing a carbon tax and recycling the revenue in the form of income tax reductions and/or using the revenue to invest in subsidization of clean energy deployment is another option. The point is that the nation does not effectively deploy cleaner and more efficient energy technologies, and therefore we lose the direct benefits of doing so as well as the "learning-by-doing" opportunities that arise from gaining experience with a technology. Other countries are doing much more than the United States in this respect.

Question 2. There are many programs in place in the federal government. Many are programs that are likely not widely known like the Navy's ocean and wave energy program. Others are popular and high profile—DOE's weatherization or EPA's

*Graph have been retained in committee files.

Energy Star programs. We want government to work more effectively with the states and private sector in this area. In part, this is an issue of good communication and coordination. Funding is important, but should also ask if some of these federal programs are effective or redundant?

Answer. No doubt there is some redundancy. I keep the most comprehensive historical database that I know of on U.S. DOE RD&D investments, and I've tried and failed to determine the energy investments of the other agencies. A study would have to be done with the full cooperation of the agencies to get a full picture of total federal energy RD&D investments. This could certainly be done.

Question 3a. Follow up—Do we need new models (programs like ARPA-E and Energy Hubs) to focus federal investments to areas of greatest need?

Answer. ARPA-E and Energy Hubs appear to be productive new models. They have special attributes, including less bureaucratic contracting and HR, ability to make multi-year grants that make them quite different from the regular DOE programs. They also appear to suffer much less earmarking.

Question b. Follow up—Are there areas where the federal government is lacking, where there are major gaps that the private sector and entrepreneurs are not utilizing?

Answer. Because of the lack of climate policy in the United States, many firms cannot justify investments in cleaner energy technologies, either within their own operations or for their own R&D facilities. This is the most pressing need. Neither the government nor the private sector is particularly willing to demonstrate low-carbon technologies because to do so is expensive, and there is no "reward" in the form of benefiting from the climate policy at the other end.

Question 4. According to the Pew Charitable Trusts, jobs in clean energy sectors grew two and a half times faster rate than jobs in the economy as whole between 1998 and 2007. Furthermore, an analysis by the University of Massachusetts, Amherst revealed that investments in clean energy could create 1.7 million net new jobs in the next ten years. Some have talked about all the jobs in the traditional energy industry. Can you comment about the potential for these clean energy jobs as factor in economic recovery?

Answer. I am optimistic, but these jobs will only materialize if there is a market for clean energy. Currently that market mainly resides outside the United States. The U.S. government will need to enact some energy policies to incentivize the use of cleaner energy technologies, which in turn will create a market for clean-tech firms and workers.

I appreciate this opportunity to be of service to the Committee.

RESPONSES OF ETHAN ZINDLER TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. Must the US match China's level of investment?

Answer. First, let me reiterate what I told the committee in my oral testimony. The opinions I express here are mine alone, not those of Bloomberg LP.

In my view, the actual number of dollars that get deployed into a given country's clean energy sector is not the most relevant metric in judging which country is most competitive in the global marketplace. However, the total funds invested figure does signify investor confidence in a given market.

Before continuing, let me clarify one point: the more than $50bn that was invested into Chinese clean energy companies and projects in 2010 did not come solely from sources within China. China's wind and solar companies regularly raise funds on the public stock exchanges in New York or Hong Kong. For instance, wind turbine manufacturer Xianjiang Goldwind Science & Technology Co. Ltd. raised just over $1bn on the Hong Kong exchange in October 2010. There has also been a limited amount of Western capital that has gone toward financing China-based power-generating projects. A substantial portion of the China clean energy boom has been financed with Western capital.

The more relevant metric in discerning if a country is a global leader is whether it can manufacture clean energy equipment at the most competitive cost. In that regard, in the conventional polysiliconbased photovoltaics (PV) sector, China is the clear leader. The country's PV players produce the majority of PV cells sold globally and do so typically at a cost approximately 10% below their Western counterparts.

China's competitive position in the global wind market is less clearly defined. While manufacturers there clearly are willing to sell wind turbines on the international market at a significant discount compared to those made in the US, Germany, or Denmark, it is unclear whether there will be buyers. Questions remain about the quality and long-term durability of Chinese-made equipment. Today,

Western financial institutions are reluctant to finance wind farms that use Chinese-made equipment for this reason.

As far as the US is concerned, the question should be much less about where the country stands today than about where it aims to be five, 10 or 15 years from now when clean energy technologies become even more cost competitive on an un-subsidized basis. The day is coming soon when a homeowner or small business person will be able to install a new PV system on his roof and earn a high return on investment without the benefit of any local public programs. Will the US be home to the manufacturing plants that make the equipment at that time? In that regard, prospects at the moment do not look terribly promising, given the rate at which other countries are attracting investment and scaling up manufacturing.

It would be wrong to count the US out of the global clean energy race, however. The country is home to an extraordinary culture of innovation and each year attracts the vast majority of clean energy venture capital. Significant further advances will be required in various clean energy technologies for them to become cost-competitive on a wider scale. The US could well be home to these breakthroughs.

Question 1.2 What is the effect of tightening margins on the PV value chain? Is there still an incentive for US companies to participate?

Answer. How and why US manufacturers might act based on long-term opportunities is unclear. But one thing is apparent at this point: margins in some segments of the PV production value chain have essentially disappeared in recent months. That will no doubt impact strategic decisions by various players in the market.

Each month, Bloomberg New Energy Finance surveys over 100 buyers and sellers of PV equipment at key stages of the value chain for our Solar Price Index. The May edition of the Index found PV prices plummeting overall in the face of weakening demand from various markets around the world. While this is potentially very good news for consumers looking to install PV systems, it is bad news for equipment makers.

Specifically, for what we refer to as "International" (non-Chinese) PV cell makers, margins have virtually disappeared entirely. The same is true of International ingot and wafer makers. The news is actually not much better for Chinese makers of cells, ingots and wafers. They too have seen their margins shrink in recent months due to over-supply in the market.

Not all parts of the PV value chain have been equally impacted, however. International and Chinese module makers continue to enjoy strong margins, along with polysilicon producers. The PV sector has seen its share of mini-booms and busts over just the past five years and the current potential trend may not be long-lived. In the short run though we anticipate that those manufacturers in segments of the value chain still enjoying margins may start to feel the pinch more in coming months.

Question 1.3 How significant is the "Valley of Death" given that financial markets appear to have rebounded?

Answer. The old adage that banks will always be the first in line to finance your second project remains true. These financial institutions are simply are too risk-adverse to finance on their own a first demonstration-scale project, particularly in light of the events of the past several years. Meanwhile, venture capitalists, while willing to take plenty of risk, typically lack the funds to bankroll a project requiring $200m or more. In effect, there exists in the market today no private player with the right risk/reward profile to unilaterally finance new energy technologies looking to scale up.

We do not anticipate this situation to change any time soon. It should be noted that even at the height of the recent financial boom—when financial institutions were willing to take the greatest amount of risk—new energy start-ups regularly had trouble raising funds for new commercial-scale projects.

In addition, current regulatory structures governing the power generation sector are not set up to encourage risk taking. Electricity generation and delivery is primarily regulated at the state level by public utility commissions whose primary mission is to insure power is delivered to ratepayers reliably and at lowest cost. This makes it all the harder for projects employing new technologies to enter the mainstream.

Responses of Ethan Zindler to Questions From Senator Coons

Question 2.1 Is $15bn per year in federal spending needed to spur clean energy's development in the US?

Answer. It is not my place as a clean energy industry analyst to render judgment on what is realistic for the US government to spend, given the current fiscal situation. However, I will share some basic data our firm has collected on how much gov-

ernments around the world have committed to clean energy in recent years. By Bloomberg New Energy Finance's count, a total of $194.3bn globally was committed in stimulus specifically for clean energy starting in January 2009. Since then, a bit over half those funds has been spent, in our estimation. While the US and China led the pack in terms of funds committed with $111bn between them, they came nowhere close to South Korea ($32.2bn) in terms of funds committed on a per-capita basis.

As mentioned in response to Senator Bingaman's question 3 (above), there remains a fundamental challenge for new energy technologies that have yet to be proven at scale and seek to break into the mainstream of the electricity-delivery infrastructure. Private sector financing alone clearly will be insufficient. That of course raises the prospect of government involvement.

Question 2.2. Are some federal programs supporting clean energy in the US redundant?

Answer. As a taxpayer, I would always like my policy leaders to be asking whether the government programs I'm paying for are effective and non-redundant. However, while the US federal government has involved itself in myriad ways in the clean energy sector, I cannot say that I have seen any major redundancies. The programs you cite above are quite different in their own ways. The Navy may be helping to foster the next generation of marine power technologies. DOE's weatherization program seeks to improve the energy efficiency of buildings while its Energy Star program seeks to improve the efficiency of refrigerators, dishwashers, and other appliances. These are all significantly different goals.

Question 2.2a Follow up—Do we need new models (programs like ARPA-E and Energy Hubs) to focus federal investments to areas of greatest need?

Answer. In my view, the area that requires support now and will undoubtedly need support in the future involves energy technologies that have been proven at the lab or even pilot scale, but have yet to be tried at demonstration or commercial scale in the field. This so-called "Valley of Death" conundrum (addressed above in response to questions from Senator Bingaman) appears to be intractable. If the US wants to be a global leader in clean energy technologies, it must address this issue in particular, above all others.

Question 2.2b Follow up—Are there areas where the federal government is lacking, where there are major gaps that the private sector and entrepreneurs are not utilizing?

Answer. Please see answers to prior questions above. The government has an important role to play in helping new clean energy technologies scale up by assisting with first-project financing support.

Question 2.3 What is the potential for clean energy jobs in the US economy?

Answer. Clearly, hopes are high that clean energy will prove to be a major engine of job growth as the US economy continues to rebound. It is our view that the sector can indeed play an important part in the ongoing recovery. That said, we would argue that the greatest economic opportunity presented by this sector probably lies 5, 10, or 15 years in the future at the point when new wind, solar, and geothermal capacity can be deployed nearly everywhere at lower cost than conventional generating technologies—without subsidies. Today, national renewable energy markets tend to rise and fall in direct correlation with the implementation or removal of supportive policies, including subsidies. In the not too distant future, that will no longer be the case; it will purely be the economics of clean energy that will drive deployment. That is when the greatest economic opportunity will arrive.

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